Original Article

EFFECT OF DYNAMIC EXERCISE IN CARDIAC EJECTION FRACTION IN BOTH ATHLETES AND SEDENTARY INDIVIDUALS

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ABSTRACT

Background and introduction: Regular Dynamic (Aerobic) exercise induces significant physiological adaptations of cardiac functioning in comparison to non exercising (Sedentary life style) individuals. This dynamic exercise showed complex cardiovascular physiological adaptations which allowed higher peak working capacity with a lesser heart rate, saving energy hence making it more efficient than in the controls.

Materials and Methods: In the present study was conducted on male subjects, their age ranging from 20-25 years, who are non smoking and non-alcoholic.

Results: The heart rate decreased in the athletes when compared to the sedentary individuals both at rest and during exercise, increasing diastolic filling time, increased ventricular mass and ventricular end diastolic volume, thus enhancing the left ventricular functional capacity.

Conclusion: Dynamic exercise which brings changes in serum lipoprotein levels, reducing the risk of coronary artery disease, serum glucose levels and total peripheral resistance which in turn reduces the risk of Diabetes mellitus and Hypertension respectively. Hence physicians should not only focus on smoking habits, diet, weight and medications, but also advice regular aerobic or dynamic exercise which increases cardiovascular efficiency, mental alertness and physical fitness.

KEYWORDS: Maitland; Dynamic Exercise; Cardiac ejection; Left ventricle; Sedentary Individuals; Athletes; Stroke volume; Heart Rate; Cardiac output.

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INTRODUCTION

Science of exercise is concerned with the human being movement. The resting state has traditionally considered as a convenient form of reference both for reporting the physiological behavior of the various body systems.

The term 'aerobic' 'isotonic' and 'dynamic' are used interchangeably refer to activity that is predominantly fuelled by oxidative phosphorylation (aerobic) is performed against a constant load (isotonic) and involves the rhythmic contraction of flexor and extensor muscle groups (dynamic). The term 'anaerobic' 'isometric' and 'static' refer to activity that is predominantly fuelled by an aerobic breakdown of glucose to lactate. This type of exercise is performed at a relatively constant muscle length (isometric) and in its pure form involves no movement (static). In any dynamic activity at high work output, both aerobic and anaerobic pathways are used for the production of adenosine triphosphate (ATP).

The left ventricle responds to isotonic exercise training with an increase in stroke volume as well

as cardiac output mediated by an increase in contractility. Ejection fraction in athletes increased significantly at peak of exercise through Frank-Starling mechanism.

So an effort has been made to compare the left ventricular function during systolic and Diastolic phases by echo-cardiography and Doppler techniques during maximal exercise in a group of runners compared with sedentary controls.

MATERIALS AND METHODS

The present study was conducted on male subjects, their age ranging from 20-25 years, who are non smoking and non-alcoholic with the help of physiology department, Kakatiya Medical College.

The criteria for selection of controls based on the fact that they have not been trained or exposed to any sort of Athletic activity prior to the present study. In this context, even the individuals who are subjected to any type of regular recreational sports activity were deliberately excluded from this study. Thus, the controls are individuals whose physical activity is minimal in their daily life e.g.: shopkeepers.

The criteria for selection of Athletes based on the fact that they have been trained or exposed to regular running for at least 3-4 years prior to the present study.

Each subject was medically examined and their past medical history has been carefully evaluated solely aimed at excluding those with cardiac or pulmonary disease or hypertension (or) diabetes. Thus unhealthy subjects were excluded and only the suitable subjects were accepted for this study.

Prior to the study each subject was informed in detail of its objectives and the aim of the research protocol and the methods to be used. Their consent was obtained. They were well educated and motivated so as to afford the best cooperation in various exercise protocols. In this study the Athletic individuals numbering 25 are grouped as Group A and the sedentary individuals also numbering 25 are grouped as B.

Experimental Protocol:

For the measurement of Dynamic exercise, the subjects were asked to run for 5 minutes and 10 minutes or otherwise it can also be done by asking them to run 1km and 3kms.

Before the actual procedure is start volunteer is subjected to a preceding period of rest ranging from ½ hr to 1 hr. When subject is ready to participate in the exercise protocol, the resting heart rate and blood pressure are recorded. The heart rate is recorded by counting the pulse rate by palpating the radial pulse. Then the blood pressure both systolic and diastolic was recorded by using the mercury sphygmomanometer and the stethoscope. These recordings are made while the subject is made to lie flat on the table near the Echocardiograph.

In this particular study the left ventricular functional capacity in Athletes is (numbering 25 group-A) compared with sedentary individuals (numbering 25 group –B).

First the resting values are taken in both the groups and the parameters selected for the study are Left Ventricular End Diastolic Volume (LVEDV) and Left Ventricular End Systolic Volume (LVESV) and also the stroke volume is measured. By multiplying the heart rate with the stroke volume we get the cardiac output. The ejection fraction is calculated by the formula:

$$\frac{(\text{LVEDV-LVESV})}{\text{LVEDV}} \times 100$$

After making the initial recording of the above parameters at rest the subject is instructed to run for 5 minutes, and the respective parameters are recorded as previously. And then the subject is allowed to take rest for about ½ hr to 45mins. And when the parameters reach the resting values, the subjects are asked to run for 10 min and immediately all the parameters were recorded.

All the subjects of both group A (Athletes) and group B (Sedentary) were exposed to test protocol.

Statistical Analysis:

Data was reported as mean and standard deviation (±SD). Means are compared between two groups by (students unpaired) t-test.

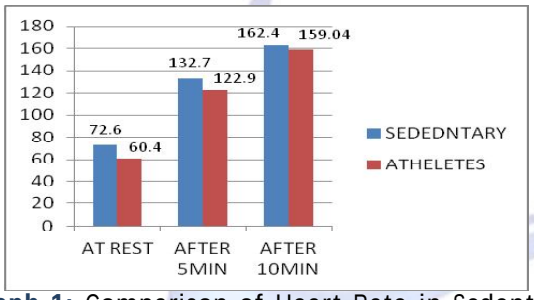
A p value of <0.05 was considered statistically significant.

RESULTS AND TABLES

In the present study the following results were obtained.

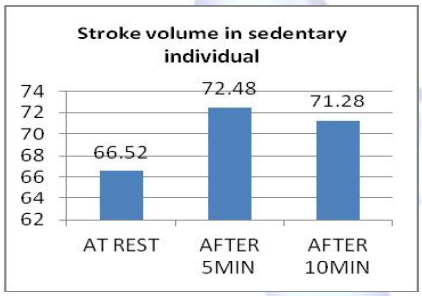
Resting conditions:

The mean heart rate in athletes at rest (60.4±2.00) is less than in the sedentary individuals at rest (72.6±1.35) (Table. 2). The mean heart rate in athletes at 5 min exercise (122.9±2.16) is less than in the sedentary individuals (132.7±2.07) (Table. 4). The mean heart rate in athletes after 10 min exercise (159.04±2.00) is less than in the sedentary individuals (162.4±1.85) (Graph-1).



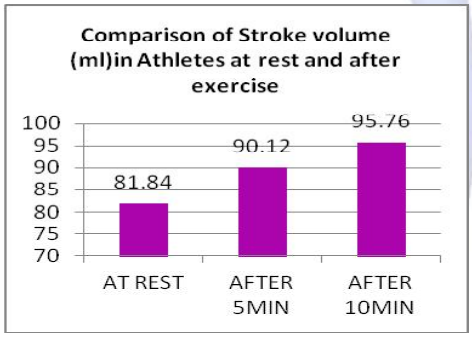
Graph 1: Comparison of Heart Rate in Sedentary individual and Athletes at Rest and after exercise.

The mean stroke volume in sedentary individuals at rest (66.52±1.12) (Table. 2) was less than in the sedentary individuals at 5 min exercise (72.48±1.50) (Table. 4) and after 10 min exercise (71.28±1.63) (Table. 6) (Graph-2).



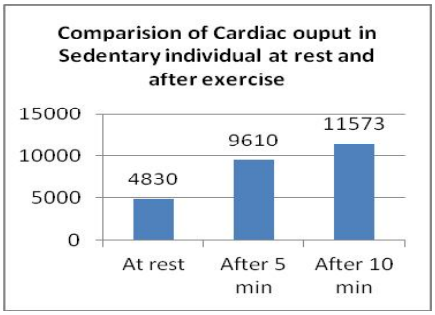
Graph -2: Comparison of Stroke Volume (ml) in sedentary individual at rest and after exercise.

The mean stroke volume in athletes at rest (81.84±1.14) (Table. 2) was less than in the athletes at 5 min exercise (90.12±1.30) (Table. 4) and after 10 min exercise (95.76±1.33) (Table. 6) (Graph-3).



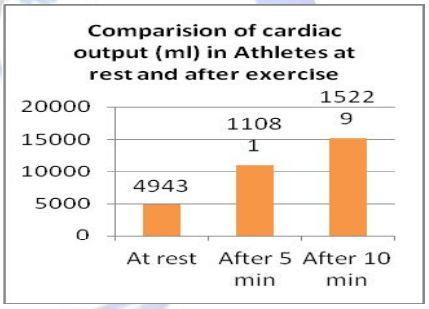
Graph -3: Compassion of Stroke volume (ml) in athletes at rest and after exercise.

The mean cardiac output in sedentary individuals at rest (4830±106.1) (Table. 2) was less than in the sedentary individuals at 5 min exercise (9610±261) (Table. 4) and after 10 min exercise (11573±281) (Table. 6) (Graph-4).



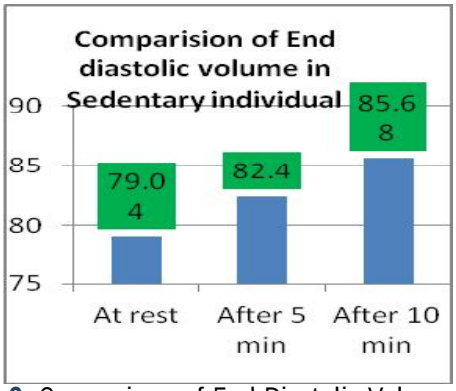
Graph -4: Comparison of Cardiac output (ml) in sedentary individual at rest and after exercise.

The mean cardiac output in athletes at rest (4943±180.47) (Table. 2) was less than in the athletes at 5 min exercise (11081±254.75) (Table. 4) and after 10 min exercise (15228±308.53) (Table. 6) (Graph-5).



Graph -5: Comparison of cardiac output in athletes at rest and after exercise.

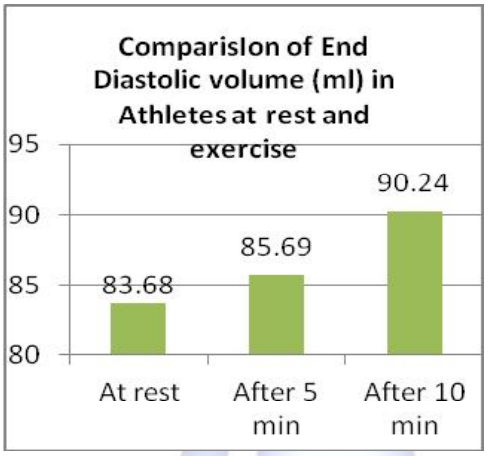
The mean end diastolic volume in sedentary individuals at rest (79.04±216) (Table.1) is less than in the athletes at 5 min exercise (82.4±2.16) (Table. 3) and after 10 min exercise (85.68±1.49) (Table. 5) (Graph-6).



Graph-6: Comparison of End Diastolic Volume (ml) in sedentary individual at rest and after exercise.

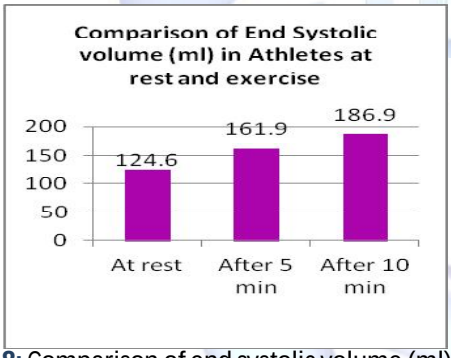
The mean end diastolic volume in athletes at rest (83.63±1.60) (Table. 1) was less than in the athletes at 5 min exercise (85.69±1.60)

(Table. 3) and after 10 min exercise (90.24±1.76) (Table. 5) (Graph-7).



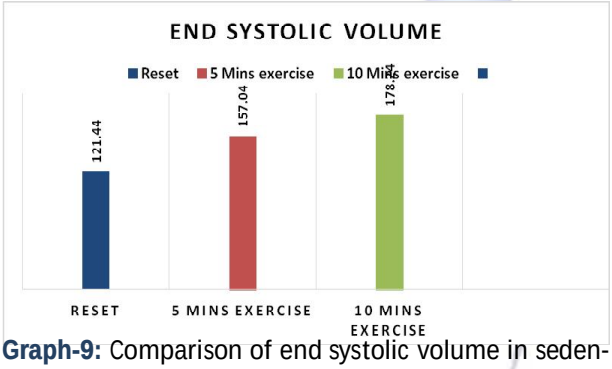
Graph -7: Comparison of end diastolic volume (ml) in athletes at rest and exercise.

The mean end systolic volume in athletes at rest (124.8±2.21) (Table. 1) was less than in the athletes at 5 min exercise (161.9±7.35) (Table. 3) and after 10 min exercise (186.9±9.43) (Table. 5) (Graph-8).



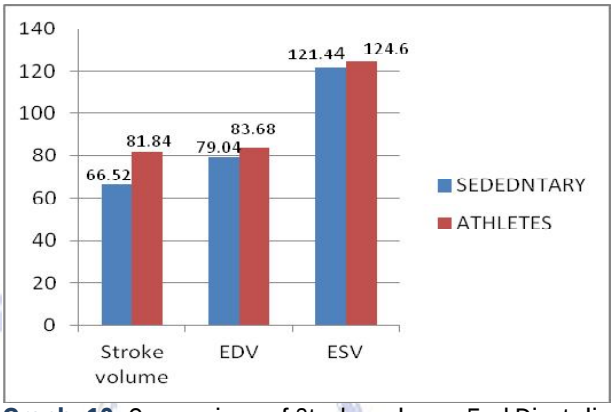
Graph -8: Comparison of end systolic volume (ml) in athletes at rest and exercise.

The mean end systolic volume in sedentary individuals at rest (121.44±2.04) (Table. 1) was less than in the sedentary individuals at 5 min exercise (157.04±2.38) (Table. 3) and after 10 min exercise (178.24±2.79) (Table. 5) (Graph-9).



Graph-9: Comparison of end systolic volume in sedentary individual at rest and exercise.

The mean stroke volume at rest in Athletes (81.84±1.14) was greater as compared to mean stroke volume in sedentary individual (66.52±1.12) (Table.2). The mean end diastolic volume at rest in athletes (83.68±1.60) was greater than mean end diastolic volume in sedentary individual (79.04±2.16) (Table. 1). The mean end systolic volume at rest in athletes (124.6±2.21) was greater than end systolic volume in sedentary individual (121.44±2.04) (Table. 1) (Graph-10).



Graph -10: Comparison of Stroke volume, End Diastolic and End Systolic volume in sedentary individual and Athletes at rest.

AFTER 5 MINUTES EXERCISE:

The mean heart rate in sedentary individual (Group B) after 5 min of dynamic exercise was (132.72±2.07) (Table.4) which is higher by 82.70% when compared to the resting heart rate of (72.64±1.35) (Table.2) of the same individuals. The mean heart rate of Athletes (Group A) after 5 min of exercise was (122.96±2.16) (Table.4) which is higher by 103.30% when compared to the resting heart rate (60.40±2.00) (Table.2) of the same individuals (Graph-1).

The mean stroke volume in sedentary individual in (Group B) after 5 min of Dynamic exercise was (72.48±1.50) (Table.4) which is 8.95% higher when compared to the resting stroke volume (66.52±1.12) (Table.2) of the same individuals (Graph-2).

The mean stroke volume in Athletes (Group A) after 5 min of Dynamic exercise was (90.12±1.30) (Table.4) which is 10.12% higher when compared to the resting stroke volume (81.84±1.14) (Table.2) in the same individuals (Graph-3).

The mean cardiac output of sedentary individual (Group B) after 5 min of Dynamic exercise was (9610 ±261) (Table.4) which is 98.96% higher when compared to the resting cardiac output value (4830±106) (Table.2) in the same individuals (Graph-4).

The mean cardiac output in Athletes (Group A) after 5 min of Dynamic Exercise (running) was (11081±254.75) (Table.4) which is 124.18% higher when compared to the resting cardiac output value (4943±180.47) (Table.2) in the same individuals (Graph-5).

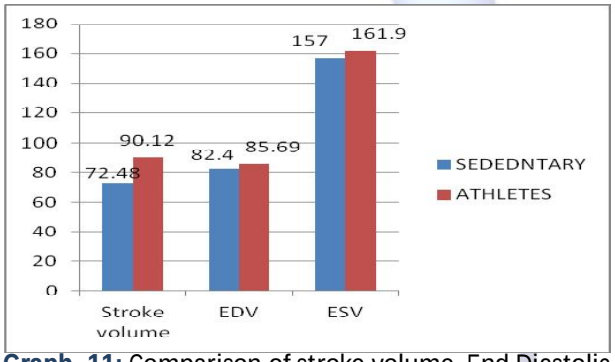
The mean end diastolic volume in sedentary individuals at 5 min exercise (82.4±2.16) (Table. 3) greater than the sedentary individuals at rest (79.04±2.16) (Table. 1) (Graph-6).

The mean end diastolic volume in athletes at 5 min exercise (85.69±1.60) (Table. 3) is greater than the mean diastolic volume in athletes at rest (83.63±1.60) (Table. 1) (Graph-7).

The mean end systolic volume in athletes at 5 min exercise (161.9±7.35) (Table. 3) is greater than the mean systolic volume in athletes at rest (124.6±2.21) (Table. 1) (Graph-8).

The mean end systolic volume sedentary individual at 5 min exercise (157.04±2.38) (Table. 3) was greater than the mean systolic volume in sedentary individuals at rest (121.44±2.04) (Table. 1) (Graph-9).

The mean stroke volume in athletes at 5 min exercise (90.12±1.30) was greater than mean stroke volume in sedentary individuals (72.48±1.50) (Table. 4).The mean end diastolic volume in athletes at 5 min exercise (85.69±1.60) was greater than end diastolic volume in sedentary individuals (82.4±2.16) (Table. 3). The mean end systolic volume in athletes at 5 min exercise (161.9±7.35) was greater than end systolic volume in sedentary individuals (157.04±2.38) (Table. 3) (Graph-11).



Graph -11: Comparison of stroke volume, End Diastolic Volume (EDV) and End Systolic Volume (ESV) in sedentary individual and athletes after 5 minutes of exercise.

AFTER 10 MIN OF EXERCISE:

The mean heart rate in sedentary individual (Group B) after 10 min of dynamic exercise was (162.48±1.85) (Table.6) which is higher by 123.67% when compared to the resting heart rate of (72.64±1.35) (Table.2) of the same individuals. The mean heart rate of Athletes (Group A) after 10 min of exercise was (159.04±20.009) (Table.6) which is higher by 263.31% when compared to the resting heart rate (60.40±2.00) (Table.2) of the same individuals (Graph-1).

The mean stroke volume in sedentary individual in (Group B) after 10 min of Dynamic exercise was (71.28±1.62) (Table.6) which is 7.15% higher when compared to the resting stroke volume (66.52±1.12) (Table.2) of the same individuals (Graph-2).

The mean stroke volume in Athletes (Group A) after 10 min of Dynamic exercise was (95.76±1.33) (Table.6) which is 17.09% higher when compared to the resting stroke volume (81.84±1.14) (Table.2) in the same individuals (Graph-3).

The mean cardiac output of sedentary individual (Group B) after 10 min of Dynamic Exercise was (11573±281) (Table.6) which is 139.6% higher when compared to the resting cardiac output value (4830±106.1) (Table.2) in the same individuals (Graph-4).

The mean cardiac output in Athletes (Group A) after 10 min of dynamic exercise (running) was (15229±308.53) (Table.6) which is 308.09% higher when compared to the resting cardiac output value (4943±180.47) (Table.2) in the same individuals (Graph-5).

The mean end diastolic volume in sedentary individuals at 10 min exercise (85.68±1.49) (Table. 5) greater than the mean end diastolic volume in sedentary individuals at rest (79.04±2.16) (Table. 1) (Graph-6).

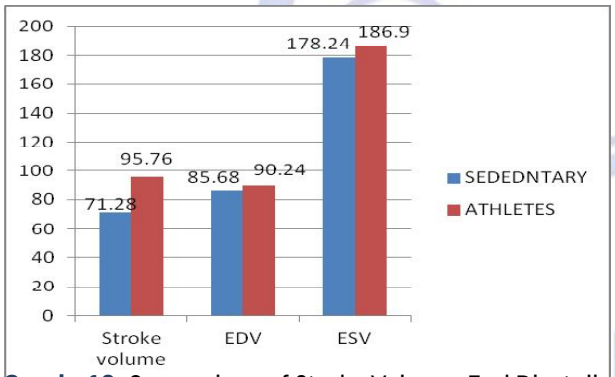
The mean end diastolic volume in athletes at 10 min exercise (90.24±1.76) (Table. 5) was greater than in the mean end diastolic volume in athletes at rest (83.63±1.60) (Table. 1) (Graph-7).

The mean end systolic volume in athletes at 10 min exercise (186.9±9.43) (Table. 5) is greater than the mean systolic volume in athletes at rest (124.6±2.21) (Table. 1) (Graph-8).

The mean end systolic volume sedentary individual at 10 min exercise (178.24±2.79)

(Table. 5) was greater than the mean systolic volume in sedentary individuals at rest (121.44±2.04) (Table. 1) (Graph-9).

The mean stroke volume in athletes at 10 min exercise (95.76±1.33) was greater than sedentary individuals (71.28±1.62) (Table. 6). The mean end diastolic volume in athletes at 10 min exercise (90.24±1.76) was greater than sedentary individuals (85.68±1.49) (Table. 5).The mean end systolic volume in athletes at 10 min exercise (186.9±9.43) greater than sedentary individuals (178.24±2.79) (Table. 5) (Graph-12).



Graph -12: Comparison of Stroke Volume, End Diastolic Volume (EDV) and End Systolic Volume (ESV) in sedentary men and athletes after 10 minutes of exercise.

	Sedentary at Rest		Athletes at Rest				
	Mean	S.D.	Mean	S.D.	T	P	Inc/dec
Systolic BP	121.44	2.04	124.64	2.21	5.253	<0.001	3%
Diastolic BP	79.04	2.16	83.68	1.6	8.63	<0.001	-57%
Pulse pressure	42.4	3.36	40.96	1.7	1.91	>0.05	-3%
Mean Art.Pressure	92.84	1.31	97.12	1.78	9.68	<0.001	5%

Table.1: Comparison of different arterial pressures in sedentary individual & athletes at rest.

	Sedentary at Rest		Athletes at Rest				
	Mean	S.D.	Mean	S.D.	T	P	Inc/dec
Heart rate	72.64	1.35	60.4	2	26.1	<0.0001	-17%
Stroke volume	66.52	1.12	81.84	1.14	47.56	<0.0001	23%
LVDV	96.6	1.15	135.28	1.91	86.56	<0.0001	40%
LVSV	32.28	1.72	53.28	0.79	55.26	<0.0001	65%
CO	4830	106.1	4943	180.47	3.869	<0.001	2%

Table.2: Comparison of Left Ventricular Systolic, Diastolic, Cardiac output and Stroke volumes in sedentary individual and athletes at rest.

	Sedentary at Rest		Athletes at Rest				
	Mean	S.D.	Mean	S.D.	T	P	Inc/dec
Systolic BP	157.04	2.38	161.92	7.35	61.54	<0.0001	3%
Diastolic BP	82.4	2.16	85.68	1.6	6.1	<0.001	4%
Pulse pressure	74.64	3.3	76.24	7.44	0.98	>0.1	2%
Mean Art.Pressure	106.92	1.6	110.88	2.78	6.04	<0.001	4%

Table.3: Comparison of different arterial pressures in sedentary individual & athletes after 5 minutes of exercise.

	Sedentary at Rest		Athletes at Rest				
	Mean	S.D.	Mean	S.D.	T	P	Inc/dec
Heart rate	132.72	2.07	122.96	2.16	16.31	<0.0001	-7%
Stroke volume	72.48	1.5	90.12	1.3	44.43	<0.0001	24%
LVDV	100.68	1.06	138.6	2.06	82.01	<0.0001	38%
LVSV	32.68	0.74	45.2	1.9	30.77	<0.0001	38%
CO	9610	261	11081	254.75	20.16	<0.0001	15%

Table.4: Comparison of Left Ventricular Systolic, Diastolic, Cardiac output and Stroke volumes in sedentary individual and athletes after 5 minutes of exercise.

	Sedentary at Rest		Athletes at Rest				
	Mean	S.D.	Mean	S.D.	T	P	Inc/dec
Systolic BP	178.24	2.79	186.96	9.43	4.43	<0.001	5%
Diastolic BP	85.68	1.49	90.24	1.76	9.88	<0.001	5%
Pulse pressure	92.56	3.48	96.72	9.88	1.98	>0.05	4%
Mean Art.Pressure	116.2	1.19	122.08	3.18	8.65	<0.001	5%

Table.5: Comparison of different arterial pressures in sedentary individual & athletes after 10 minutes of exercise.

	Sedentary at Rest		Athletes at Rest				
	Mean	S.D.	Mean	S.D.	T	P	Inc/dec
Heart rate	162.48	1.85	159.04	2.009	6.31	<0.001	-2%
Stroke volume	71.28	1.62	95.76	1.33	58.39	<0.0001	34%
LVDV	102.96	0.78	143.12	2	93.53	<0.0001	39%
LVSV	30.96	0.78	43.2	1.91	29.66	<0.0001	40%
CO	11573	281	15229	308.53	43.79	<0.0001	32%

Table.6: Comparison of Left Ventricular Systolic, Diastolic, Cardiac output and Stroke volumes in sedentary individual and athletes after 10 minutes of exercise.

DISCUSSION

In the present study the resting values of cardiac output, heart rate, stroke volume, left ventricular diastolic and systolic volume of sedentary individuals when compared to Athletes are consistent with the results of exercise studies made by Oven E.M et, al.(1990). [1]

The results of left ventricular end diastolic volume in resting individuals of both sedentary and Athletic groups when compared with the results of exercise studies show significant increase in peak diastolic filling rate done by Doppler Echocardiography studied by Brandao M.U et, al.(1993). [2]

The striking difference between the untrained individuals (sedentary) and trained (Athletes) showing lower heart rate and greater end systolic volume and greater stroke volume at rest in Athletes, was found consistent with the studies of Clausen J.P.(1977). [3, 20]

The left ventricular wall mass and left ventricular diastolic filling are increased in dynamically trained Athletes during dynamic exercise was found consistent with the study of Nixon. J.V et, al. (1991). [4]

Significant rise in Heart rate and to all lesser extent and increase in stroke volume during dynamic exercise which resulted in marked increase in Oxygen consumption, was found consistent with the study of Hossack F.(1987).[5]

Chronic dynamic exercise significantly lowers peripheral vascular resistance. There by unloading the strain of the Heart, hence reducing the Heart rate at rest when compared to sedentary individuals was found consistent with the study of Blonquist C.G. et, al. (1983). [6]

The work of Astard P.C.et, al. (1986)[7] was found consistent to prove that physically fit individuals for exercise have lower resting heart rate and also expected to be in a better physical condition.

The exercise tolerance which is significantly related to Diastolic blood pressure and left ventricular filling studied by multiple regression analysis with Echo colour Doppler by Genovesi-ebert .A et,al. (1994) [8] is also consistent with our study.

Micheal E.et, al. (1935)[9] found that long term isotonic (dynamic) exercise in trained Athletes have reduced resting heart rate and in increase in left ventricular end diastolic volume, which is found consistent with the results of our study.

Richard A.S et, al (1980) [10] while studying the effect of exercise training on left ventricular dimensions at rest and during exercise in trained students by Echocardiographic analysis found that the left ventricle responds to isotonic exercise with an increase in stroke volume both at rest and during exercise. This enhanced stroke volume may be mediated by increased end diastolic volume (Frank-starling effect) or enhanced contractile state.

Werner Zwehl et, al (1981)[11] conducted a quantitative two dimensional Echocardiographic study in 10 normal subjects performing exercise, concluded that during exercise there is an increased left ventricular ejection fraction.

Jerald L.Cohen et, al(1980) [12] the American ballet dancers described significant increase in left ventricular end diastolic internal dimensions and left ventricular mass index, along with other left ventricular parameters which are also consistent with the analysis of our study.

Charles A. et, al (1977)[13] studied the adaptive cardiac responses to isotonic training with echocardiographic measurements of cardiac dimensions and function in 20endurance runners and they were compared with 26 young sedentary control subjects. This study showed a modest degree of right and left ventricular chamber enlargement and left ventricular hypertrophy in endurance runners which suggests that isotonic training results in adaptive changes in ventricular volume and mass, slower heart rates that may be associated with more efficient pumping function (increasing stroke volume).

Ejection Fraction in athletes increased significantly at peak of exercise through Frank-Starling Mechanism. Stroke volume and cardiac output increased significantly in athletes at peak of exercise. Left ventricular diastolic function was superior in athletes than in sedentary men. Therefore, the athletes showed complex cardiovascular adjustments induced by training by Vitantona Pibello et, al (1996)[14] is also consistent with our study.

The observations of marked tachycardia, cardiac output and significant but small rise in arterial pressures during severe exercise is consistent with the study of Bevergard B.S et,al (1963). [15]

The findings of Ali A et, al (1978) [16] that the cardiovascular adaptations in trained athletes include resting bradycardia and increased cardiac output in response to maximal exercise, is consistent with our study.

Benjamin EJ et, al (1992) [17] stated that heart rate, LV systolic function and systolic blood pressure are minor determinants of Doppler indexes of diastolic function in normal subjects it is agreement with our present study.

The determination of left ventricular end diastolic volume and ejection fraction is consistent with the study of Carr KW (1979). [18]

Erickson HH et, al (1971)[19] studied that the Left ventricular end diastolic pressure and dimensions in normal subjects performing dyna-

-mic exercise when the exercise stress is severe, a Frank-Starling response with an increase in left ventricular end-diastolic pressure and dimensions occurs our study agreement with this report.

CONCLUSION

Dynamic exercise which brings changes in serum lipoprotein levels, reducing the risk of coronary artery disease, serum glucose levels and total peripheral resistance which in turn reduces the risk of Diabetes mellitus and Hypertension respectively. Hence physicians should not only focus on smoking habits, diet, weight and medications, but also advice regular aerobic or dynamic exercise which increases cardiovascular efficiency, mental alertness and physical fitness.

Conflicts of Interest: None

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