P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 5.38
IJPESH 2019; 6(5): 83-89

www.kheljournal.com
Received: 10-07-2019
Accepted: 12-08-2019

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Assessment of cardiac efficacy in relation to different proportions of aerobic and anaerobic training among elite athletes

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Abstract
Extreme advantage of the 'Sports training stimulus can be acquired when reproduce the developments on vital systems engaged with the sports'. The present investigation was assessment of cardiac efficacy in relation to different proportions of aerobic and anaerobic training among elite athletes. Forty Five (N=45) healthy male elite athletes were volunteered as subjects from different parts of Andhra Pradesh and Telangana State, India, Athletes age between 20 and 25 years. The investigator has parted them into three groups according to their events and utilization of different aerobic and anaerobic proportions. Group I is 10% aerobic and 90% anaerobic proportion (200 mtr race), Group II is 50% aerobic and 50% anaerobic proportion (1500 mtr race) and Group III is 90% aerobic and 10% anaerobic proportion (10,000 mtr race) (Edward L. Fox, 1989). The assessed parameters are cardiac output ($\dot{Q}$) at rest, Left ventricular End diastolic Volume (LVEDV) at rest and Left ventricular End Systolic volume (LVESV) at rest they were measured by M-mode Doppler echocardiography. All the subjects have been effectively contributing at National and University level competitions. Subject underwent regular training program under the direction of their regular coaches as per specialized sports event. Values attained were evaluated with data obtained from subjects. The results indicates that 90% aerobic and 10% anaerobic training group has considerably increased LVEDV and Declined the LVESV, ultimately it leads to increase $\dot{Q}$.

Keywords: Sports training, left ventricular end diastolic volume, left ventricular end systolic volume, cardiac output, different proportions of aerobic, anaerobic training

1. Introduction

"Most extreme advantage of the training stimulus can be acquired when reproduce the developments on vitality systems engaged with the sports". Expanded interest for oxygen take-up and use during activity rely upon satisfactory adjustments of the peripheral vasculature and this is encouraged by an expansion in cardiac output to enhance oxygen conveyance (Guido E Pieles, Gergely Szantho *et al*., 2014) [8].

Regular and long term exercise prompts a cardiac hypertrophy called athlete's heart. Athlete's heart is accepted that the dimensional changes influence every cardiac cavity to some extent, resulting in a balanced cardiac hypertrophy. End systolic (ESV) and end diastolic volumes (EDV) were used to govern stroke volume (SV) and$\dot{Q}$. (Scharhag *et al*., 2002).

The essential compensations of physical workout are to an upturn the cardiac output and an augmentation of the inherent ability of muscles to extract and to employ oxygen from the blood (Harsh Patel, Hassan Alkhawam *et al* 2017) [9]. The change in SV, in response to exercise associated with exercise training, is the main adaptation providing the impetus for increase in maximal $\dot{Q}$, that is why endurance trained athletes are capable of continuously increasing their SV (Gledhill *et al*., 1994) [7]. Misserli and ketelhut (1990) [16] stated that functional hypertrophy that ensues with endurance activity is categorized by abnormal or augmented coronary reserve and ventricular filling. It is well identified that sports have yields a physiological hypertrophy but the pervasiveness differs depending on the duration and intensity of training programs and kind of endurance sport performed.

Sharon A. Plowman and Denise L. Smith (2011) [21] states that myocardial oxygen consumption upsurges during dynamic aerobic workout because the heart must do more work to eject an augmented cardiac output to the functioning muscles.

The rate stress item will increment in relation to increments in heart rate and SBP, reflecting the more prominent myocardial oxygen request of the heart during activity. According to K M Gallagher (1999) [11] Resting and submaximal exercise $\dot{Q}$ are not changed by exercise training; however, maximal $\dot{Q}$ can be twice as much in elite athletes than in untrained individuals. The changes in maximal cardiac output are primarily due to changes in stroke volume because maximal heart rate (HR) is unaffected by training. $\dot{Q}$ is approximately 5L/min at rest, and the $\dot{Q}$ increases 5 to 6 L/min for every 1L/min increase in oxygen uptake during dynamic exercise. The increase in $\dot{Q}$ is due to increase in HR & SV. Maximal $\dot{Q}$ ordinarily achieve 20 to 25 L/min in normally active boys and men but are capable of reaching 40L/min in endurance trained athletes. Within physiological limits enhanced venous return increases the heart EDV stretching cardiac muscle fibers and increasing their force of contraction. During exercise there is an increase in SV resulting from both the frank-starling law of mechanism and a decreased ESV of the heart.

Endurance training is distinctive of aerobic sports with active isotonic muscular contribution such as long distance swimming and running. These events causes a slow decline in systemic arterial resistance and upsurge in venous return with a leading volume overload resting in higher LVEDV and SV (A D Andrea, J Rodmilovich, L Riegler, R Scarafile *et al*., 2018). Long term cardiovascular reworked to dynamic training yields increased maximal oxygen uptake due to augmented cardiac output and arteriovenous oxygen difference. Endurance activity mainly produces volume load on the left ventricle and resistance exercise causes mostly a pressure load (Barry J Maron, Antonio Pellicia, 2006) [16].

Sharon A. Plowman *et al*. (2011) [21] and (Poliner *et al*., 1980) states that simple to adequate exercise, upsurge in SV consequences from an augmented venous return, leading to the frank-Starling mechanism, and amplified contractility owing to sympathetic nerve stimulus, thus changes in SV arise because of LVEDV increases and LVESV decreases And also increases $\dot{Q}$. According to K. Rama Subba Reddy *et al*., 2010 [12] Parasympathetic extraction delivers the initial upsurge in $\dot{Q}$ but when this becomes deficient, sympathetic activity is amplified. Cardiovascular moments of dynamic exercise include improved HR, SV, $\dot{Q}$ and declined peripheral resistance. With systematic dynamic workout, a different other cardiovascular properties are superimpose on the acute responses.

In this examination the examiner is attempting to put a push to discover how 10% aerobic and 90% anaerobic and 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic trainings are going to impact on selected cardiovascular parameters such as $\dot{Q}$, LVEDV and LVESV which are having a straight association with the cardiac efficacy of an elite athlete.

2. Method

Forty Five (N=45) healthy male elite athletes were volunteered as subjects from different parts of Andhra Pradesh and Telangana, India. The investigator has elect 10% aerobic and 90% anaerobic and 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic proportions as independent variables, to meet this criteria fifteen men (n=15) elite athletes from 200 mtr, fifteen men (n=15) elite athletes from 1500 mtr and fifteen men (n=15) elite athletes from 10,000 mtr race respectively (Edward L. Fox, 1989) [4] who have been effectively taking an interest at National and University level sports. Subject underwent regular training program under the direction of their regular coaches as per specialized sports event. The subjects age between 20 and 25 years. The training diary revealed that volunteered elite subject athletes were not reported any injuries during their training period and their sports age is 5 to 7 years. The assessed parameters are $\dot{Q}$ at rest, LVEDV at rest and LVESV at rest they were measured by 'M-mode Doppler echocardiography (Philips CX50 ultra image system) at Lakshya Cardiac Center, Prodatur, Andhra Pradesh, India'.

2.1 Calibration and procedure

M-Mode Doppler echo cardio graph: 'M-mode Doppler echocardiography was performed on a Philips CX50 imaging ultra-image system, Philips medical systems, USA, with 2.5 to 3.5 MHz transducer for M-mode Doppler echocardiography' was used to define the $\dot{Q}$, LVEDV and LVESV.

2.2 Statistical analysis

The gathered information on chose factors has been investigated and displayed underneath. The information gathered from experimental groups on $\dot{Q}$ at rest and LVEDV at rest LVESV at rest were statistically verified for critical distinction, if any by utilizing Analysis of variance (ANOVA) and information were analyzed by utilizing pc with IBM-25, SPSS package. The degree of certainty was fixed at 0.05 for significance. To decide the significance difference among the means of three experimental groups, the Scheffe'S test was used as post-hoc test.

3. Results and Discussions

3.1 Results

3.1.1 Cardiac output at rest

The mean, standard deviation (SD) and ANOVA for the $\dot{Q}$ at rest of three independent groups were analyzed and presented in table I

The table value for significance at 0.05 level with df 2 and 42 is 3.222.

The table I show that the means of 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic groups are 4631.02, 4650.47 and 4694.43 ml/min respectively. The obtained 'F' ratio of 1.848 is less than the table value of 3.222 for df 2 and 42 required for significant at 0.05 level.

The results of the investigation indicates that there is no noteworthy contrast among 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic groups on $\dot{Q}$ at rest. Hence, it is insignificance difference among the means of three experimental groups the Scheffe'S test was not applied as post-hoc test.

The tests mean values on $\dot{Q}$ of three experimental groups are graphically depicted in Figure I.

3.1.2 Left ventricular end diastolic volume at rest

The mean, SD and ANOVA for the LVEDV at rest of three independent groups were analyzed and presented in table II

The table value for significance at 0.05 level with df 2 and 42 is 3.222.

The table II shows that the means of 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic groups are 118.45, 126.22 and 134.36 ml respectively. The obtained 'F' ratio of 238.105 is much greater than the table value of 3.222 for df 2 and 42 required for significant at 0.05 level.

The results of the investigation shows that the noteworthy difference occurs among 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic groups on LVEDV at rest. To determine the significance alteration among the means of three experimental groups, the Scheffe'S test was applied as post-hoc test and the results are presented in table II-A.

Table II-A shows that the tests mean difference on LVEDV at rest between 10% aerobic and 90% anaerobic group and 50% aerobic and 50% anaerobic group is 7.77 which is greater than the confidence interval value 1.312 at 0.05 level of confidence. The test mean difference on LVEDV at rest between 10% aerobic and 90% anaerobic group and 90% aerobic and 10% anaerobic group is 15.91 which is much greater than the confidence interval value 1.312 at 0.05 level of confidence. The test mean difference on LVEDV at rest between 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group is 8.14 which is greater than the confidence interval value 1.312 at 0.05 level of confidence. Hence, it is concluded from the results that there is a significant difference among the three experimental groups on LVEDV at rest.

From the results it was concluded that, 90% aerobic and 10% anaerobic group has increased the LVEDV at rest as compared to other two experimental groups. Further it is concluded that highest mean difference exists between 10% aerobic and 90% anaerobic group and 90% aerobic and 10% anaerobic group. The test means values on LVEDV at rest of three experimental groups are graphically presented in Figure II.

3.1.3 Left ventricular end systolic volume at rest

The mean, SD and ANOVA for the LVESV at rest of three independent groups were analyzed and presented in table III

The table value for significance at 0.05 level with df 2 and 42 is 3.222.

The table III shows that the means of 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group are 35.82, 34.72 and 32.28 ml respectively. The acquired 'F' ratio of 88.862 is greater than the table value of 3.222 for df 2 and 42 required for significant at 0.05 level.

The results of the study shows that there is a significant difference among 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group on LVESV at rest. To determine the significance difference among the means of three experimental groups, the Scheffe'S test was used as post-hoc test and the results are presented in table III-A.

Table III-A shows that the tests mean difference on LVESV at rest between 10% aerobic and 90% anaerobic group and 50% aerobic and 50% anaerobic group is 1.10 which is greater than the confidence interval value 0.489 at 0.05 level of confidence. The test mean difference on LVESV at rest between 10% aerobic and 90% anaerobic group and 90% aerobic and 10% anaerobic group is 3.54 which is much greater than the confidence interval value 0.489 at 0.05 level of confidence. The test mean difference on LVESV at rest between 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group is 2.44 which is greater than the confidence interval value 0.489 at 0.05 level of confidence. Hence, it is completed from the results that there is a significant alteration among all the three experimental groups on LVESV at rest.

From the outcomes it was resolved that, 90% aerobic and 10% anaerobic group has significantly decreased the LVESV at rest as compared to 10% aerobic and 90% anaerobic group and 50% aerobic and 50% anaerobic group. Further it is decided that highest mean difference exists between 10% aerobic and 90% anaerobic group and 90% aerobic and 10% anaerobic group.

The test means values on LVESV at rest of three experimental groups are graphically depicted in Figure III.

3.2 Discussions on findings

The findings show that of the study shows that the endurance runners have extreme changes in cardiovascular system as compared to sprinters. In this investigation 10% aerobic and 90% anaerobic, 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic groups has acquired cardiovascular alterations but 90% aerobic and 10% anaerobic group endured great cardiovascular alterations as compared to other two experimental groups.

3.2.1. Cardiac Output at Rest

From the consequences of the investigation it has been determined that, the 10% aerobic and 90% anaerobic, 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic groups has improved cardiac output at rest. Further the result indicates that there no noteworthy change in $\dot{Q}$at rest among the three experimental groups.

Concentrated physical exercise is related with focal and fringe cardiovascular adjustments that encourage the generation of enormous and continued cardiac output and improve the extraction of oxygen from practicing muscle for aerobic glycolysis (John Rawlins, Amit Bhan and Sanjay Sharma (2009) [10]. Aerobic exercise upsurges the mechanical efficacy of the heart by aggregate cardiac output (Anju Madan Gupt and Mukesh Kumar *et al*., 2015) [3].

High SV is upheld with low heart rate, while low SV is kept up with a high HR. Likewise regular exercise makes the progression of the venous blood smooth, in this way expanding the amount of blood coming back to diastolic heart, which increment$\dot{Q}$. (Maron, 1986) [15]. Enrique Z. Fishman Michael Motro *et al*. (2002) [6] viewed that noticeably augmented $\dot{Q}$ fundamentally through prominent increment in SV; their activity HR was like that of stationary people.

Turkvich *et al*. (1988), concluded highly trained endurance athletes heart have adjusted to training, by radically growing SV, lower HR can give ideal $\dot{Q}$. According to Richard Allen (1999) [19], the cardiovascular system achieves this by increasing $\dot{Q}$ and redistributing blood Stream to the dynamic muscle by means of neural procedures of the hemodynamic reactions and local regulation of the flow with in the active muscle. This blood (250 to 400 ml/100g /min) neural guideline of the cardiovascular system directs hemodynamics responses by increasing HR, SV, $\dot{Q}$ and O_2 extraction at the tissue level. Scharhag *et al*., 2002 revealed that the cardiac output at rest will be unaffected and it will be the same in athletes as well as in controlled group.

The research findings of the present investigation are in conformity with the above research evidence.

3.2.2 Left Ventricular End Diastolic Volume at Rest

From the consequences of the investigation it has been decided that, 10% aerobic and 90% anaerobic, 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic group has significantly increased the LVEDV at rest however

50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic groups have significantly increased LVEDV at rest as compared to 10% aerobic and 90% anaerobic group. The results indicate that the noteworthy difference occurs among three groups on LVEDV at rest.

Scharhag J *et al*., (2002) revealed that endurance athletes showed greater in left and right ventricular end diastolic and systolic volume. In addition, the comparative proportion of Left ventricular end diastolic volume and right ventricular end diastolic volume in two groups shows that aerobic exercise induces both ventricular myocardial hypertrophy and a balanced ventricular dilation.

Aerobic exercise implicates movement of great muscle groups. The marked arteries' enlargement i.e. volume overload that creates Left ventricular eccentric hypertrophy by aggregate venous return and accordingly LVEDV is augmented and LVESV is decreased, therefore, SV and EF are amplified (Pluim BM and Zwinderman AH *et al*., 2000) [17].

Hence, the researcher concluded that, 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic groups have increased LVEDV at rest. The present investigation concludes that the outcomes are inconformity with the above research evidences.

3.2.3 Left Ventricular End Systolic Volume

From the consequences of the investigation it has been decided that, 10% aerobic and 90% anaerobic, 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic group has significantly increased the LVEDV at rest however 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic groups have significantly increased LVEDV at rest as compared to 10% aerobic and 90% anaerobic group. The results indicate that the noteworthy difference occurs among three groups on LVEDV at rest.

From the consequences of the investigation it has been determined that 10% aerobic and 90% anaerobic, 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic group has significantly decreased the LVESV at rest however 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic groups have significantly decreased LVESV at rest as compared to 10% aerobic and 90% anaerobic group. The result indicates that the noteworthy dissimilarity exists among three groups on LVESV at rest.

Stella S. *et al*., (2016) [22] At a squat exercise capacity, left ventricle filling pressure and end diastolic volume upsurges are linked to a greater SV, at a great work load, an augmented HR is followed by a reduction in the end diastolic volume against an upsurge in filling pressure. Therefore, stroke volume may be continued by reduction in the LVEDV. Regular sports activity typically instigates myocardial structural and utilitarian changes. (Rawlins j, Bhan A, sharma S, 2009) [18] LV chamber estimations are predominantly associated with this adjustment. (Alessio De Luca, Laura Stefani *et al*., 2011) [2].

Sharon A. Plowman and Denise L. Smith (2011) [21] noted that the effects of short term, light to moderate submaximal aerobic exercise was the contractility of the myocardium is also enhanced by the sympathetic nervous system, which is activated during physical activity. Thus, an increase in the left ventricular end diastolic volume and a decrease in the left ventricular end systolic volume account for the increase in stroke volume during light to moderate dynamic exercise. Hence, the researcher concluded that, 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic groups have significantly decreased LVESV at rest. The present study concludes that the findings are in conformity with the above research evidences.

Noticed that the impacts of short period, light to moderate submaximal aerobic exercise was the contractility of the myocardium is additionally upgraded by the sympathetic nervous system, which is initiated during physical activity. In this manner, an upsurge in the LVEDV and a reduction in the LVESV represent the increment in SV during light to moderate dynamic activity.

Hence, the investigator concludes that, 50% aerobic and 50% anaerobic and 90% aerobic and 10% anaerobic training have essentially diminished LVESV at rest.The present investigation infers that the discoveries are in conformity with the above research confirmations.

3.3. Tables and Figures

Table 1: Analysis of variance for the cardiac output at rest data on 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group.

Test	10% Aerobic and 90% Anaerobic Group	50% Aerobic and 50% Anaerobic Group	90% Aerobic and 10% Anaerobic Group	Source of Variance	df	Sum of Squares	Mean Squares	Obtained 'F' Ratio	Table 'F' Ratio
$\bar{X}$	4631.02	4650.47	4694.43	B:	2	31653.66	15826.83	1.848	3.222
σ	125.25	49.99	88.29	W:	42	359624.26	8562.48		

*Significant at 0.05 level of confidence.
The table value for significance at 0.05 level with df 2 and 42 is 3.222.

Table 2: Analysis of variance for the left ventricular end diastolic volume at rest data on 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group

Test	10% Aerobic and 90% Anaerobic Group	50% Aerobic and 50% Anaerobic Group	90% Aerobic and 10% Anaerobic Group	Source of Variance	df	Sum of Squares	Mean Squares	Obtained 'F' Ratio	Table 'F' Ratio
$\bar{X}$	118.45	126.22	134.36	B:	2	1899.59	949.80	238.105*	3.222
σ	2.14	2.22	1.56	W:	42	167.54	3.99		

*Significant at 0.05 level of confidence.
The table value for significance at 0.05 level with df 2 and 42 is 3.222.

Table 2A: Scheffe's post hoc test for left ventricular end diastolic volume at rest on the difference between 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group

10% Aerobic and 90% Anaerobic Group	50% Aerobic and 50% Anaerobic Group	90% Aerobic and 10% Anaerobic Group	Mean Differences	Confidence Interval 0.05 Level
118.45	126.22	-	7.77*	1.312
118.45	-	134.36	15.91*	1.312
-	126.22	134.36	8.14*	1.312

*Significant at the 0.05 level of confidence

Table 3: Analysis of variance for the left ventricular end systolic volume at rest data on 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group

Test	10% Aerobic and 90% Anaerobic Group	50% Aerobic and 50% Anaerobic Group	90% Aerobic and 10% Anaerobic Group	Source of Variance	df	Sum of Squares	Mean Squares	Obtained 'F' Ratio	Table 'F' Ratio
$\bar{X}$	35.82	34.72	32.28	B:	2	98.476	49.238	88.862*	3.222
σ	0.50	0.94	0.72	W:	42	23.272	0.554		

*Significant at 0.05 level of confidence.
The table value for significance at 0.05 level with df 2 and 42 is 3.222.

Table 3A: Scheffe's post-hoc test for left ventricular end systolic volume at rest on the difference between 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group

10% Aerobic and 90% Anaerobic Group	50% Aerobic and 50% Anaerobic Group	90% Aerobic and 10% Anaerobic Group	Mean Differences	Confidence Interval 0.05 Level
35.82	34.72	-	1.10*	0.489
35.82	-	32.28	3.54*	0.489
-	34.72	32.28	2.44*	0.489

*Significant at 0.05 level of confidence.
The table value for significance at 0.05 level with df 2 and 42 is 3.222.

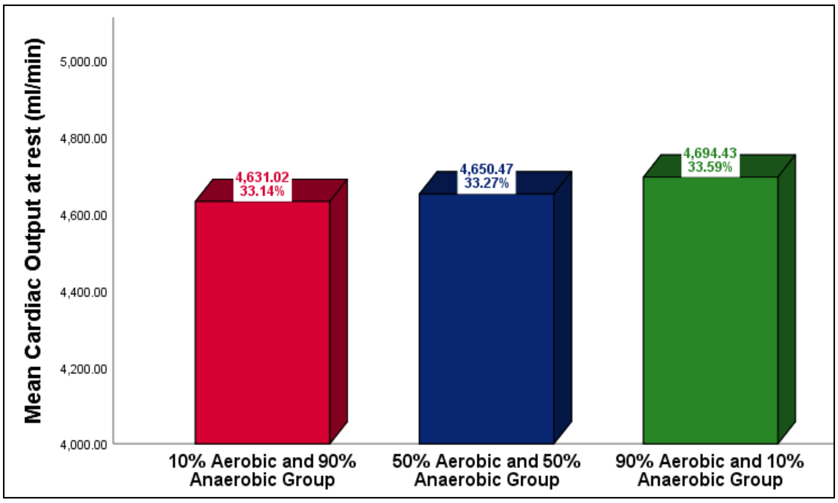

Fig 1: Bar diagram on cardiac output at rest means of 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group

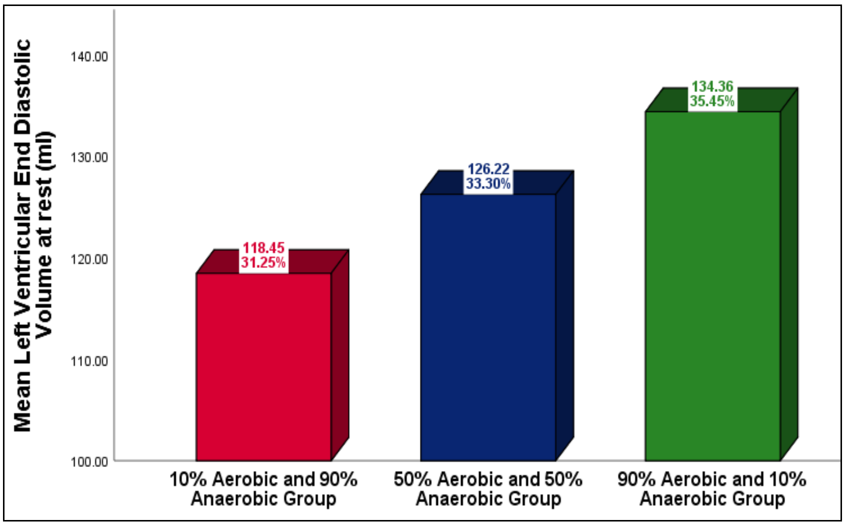

Fig 2: Bar diagram on left ventricular end diastolic volume at rest means of 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group

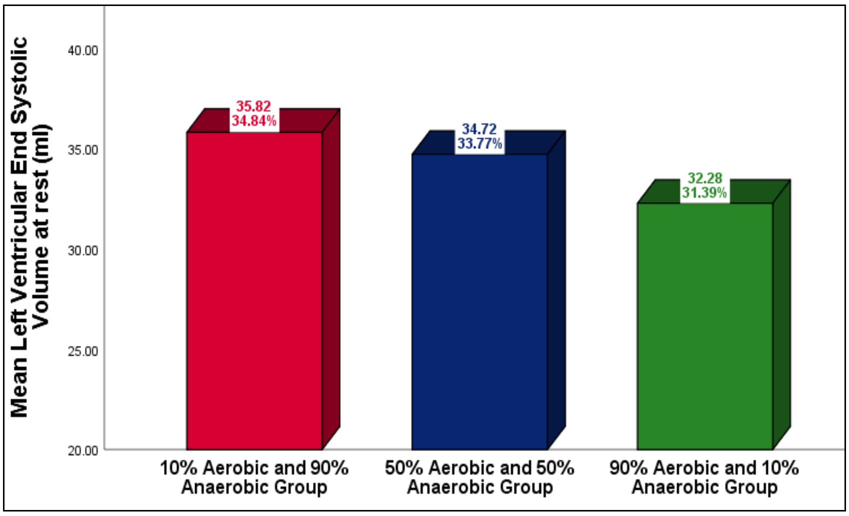

Fig 3: Bar diagram on left ventricular end systolic volume at rest means of 10% aerobic and 90% anaerobic group, 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group

4. Conclusions

1. Cardiac Output at rest has no difference among+ three experimental groups
2. Left ventricular end diastolic volume has increased by 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group compared to 10% aerobic and 90% anaerobic group.
3. Left ventricular end systolic volume has significantly reduced by 50% aerobic and 50% anaerobic group and 90% aerobic and 10% anaerobic group compared to 10% aerobic and 90% anaerobic group.

5. Recommendations

90% aerobic and 10% anaerobic training proportions is the better proportion to increases the LVEDV and decreases the LVESV ultimately it leads to increase the cardiac output

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