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# IMPERATIVE ANALYSIS ON THE INTERACTIONS OF HEART RATE AND STROKE VOLUME AMONG ELITE WOMEN

**Polakala Krishna Moorthy[1], Dr K Rama Subba Reddy[2]**

1. Research Scholar, PhD Regular, DPESS, Yogi Vemana University, Kadapa, AP, India.
2. Research Supervisor, Head, DPESS, Yogi Vemana University, Kadapa, AP, India.

## ABSTRACT:

The substantial benefit of sports training simulation is realized when the development of the key systems engaged in sports is simulated. Whenever one engages in a purposeful, systematic physical and physiological training regimen, the body will inevitably undergo significant changes. Based on the existing facts of science of sports training, the researcher is focusing on how various demands from sports like long distance running, middle distance running and weight lifting will have a good effect on specific cardiovascular parameters. To meet the purpose the investigator has chosen (N=45) women volunteered elite athletes of each (N=15) of long distance running group, middle distance running group and weight lifting group athletes between 18 and 22 years. All the volunteered elite athletes are trained by their coaches for about 7 to 9 years. The criterian parameters are heart rate at rest and stroke volume at rest. The criterion measures were measured by using M-Mode Doppler Echo Cardiography. The level of significance is set at 0.01 level of assurance, since the data was procured by using highly sophisted scientific gadget. The study concluded that a regular and systematic long distance running, middle distance running and weight lifting trainings significantly brought changes in selected variables as compared to the normal reference values. Further, it is concluded that the long distance running group has lowered the heart rate at rest as compared to other experimental groups and the stroke volume at rest is increased by Long distance running group as compared to other experimental groups. In ordered to find out the significant difference analysis of variance (ANOVA) was employed. When the 'F' ratio is significant, the Scheffe's post-hock test was used to find the paired mean significant difference, if any, among the groups of chosen parameters.

**KEYWORDS: Long distance running, Middle distance running, Weightlifting, Heart rate at rest, Stroke volume at rest.**

## INTRODUCTION:

There is a linear relationship between heart rate and exercise oxygen consumption per minute ($VO_2$). Heart rate increases linearly with increasing oxygen consumption in both trained and untrained individuals. It is important to remember that once the stroke volume reaches the maximum, increase in cardiac output can be achieved only through increases in heart rate. Endurance training decreases the maximal heart rate from about 200 beats per minute to somewhere around 185 to 190 beats per minute/ Increase in the quantity of stroke volume after endurance training is accompanied by a decrease in the heart rate during the maximal exercise. This means that the maximal heart rates of trained individuals are obtained at relatively higher workloads and $VO_2$ levels than in untrained subjects. Although heart rate will generally level off within 2 to 3 minutes at a given submaximal workload, at higher workloads it takes progressively longer to plateau or attain a steady-state rate. At even higher Workloads a definable maximum heart rate is attained, which decreases with age. The resting heart rates in highly trained athletes may be as low as or lower than 40 to 45 beats per minute. On the other hand, in healthy but untrained subjects, resting heart rates may be as high as 80 to 90 beats per minute. Thus, it is important to understand that, a relatively slow heart rate, coupled with a relatively large stroke volume, signifies an efficient circulatory system. During exercise the heart rates of untrained individual's increases steadily at a faster rate, the heart rates of the athletes increased at lesser rate and to a lower level. Hence, it is possible for the athlete to do more work and achieve high oxygen consumption before reaching the maximal heart rate.

It is important to remember that the type of exercise definitely influences the increase in heart rate. For example, the greatest acceleration of the heart occurs in exercises of speed such as sprint running, whereas the smallest increase takes place in strength exercise such as weight lifting and throwing. Also, in steady state endurance events such as distance running, the heart rate increases and reaches a plateau at about 70 to 80 percent of the heart rate maximum. However, heart rate recovery to normal values takes longer following cessation of the endurance exercise. **Dr. Amrit Kumar R. Moses (1995).**

Two important physiological mechanisms regulate stroke volume. They are enhanced diastolic filling and greater systolic emptying. Increased venous return causes greater ventricular filling during the diastolic phase of the cardiac cycle. This increase in venous return to the ventricles stretches the cardiac muscles and causes a powerful contraction of the heart. Thus, in addition to the normal stroke volume, the extra blood that entered the ventricles is expelled forcefully. For many years it was believed that the stroke volume increase during exercise was by the mechanism postulated by Frank and Starling in early 1900's. This phenomenon known as the Starling's law of the heart, states that stroke volume increases in response to an increase in the volume of blood filling the heart ventricles during ventricular diastole or relaxation. This increased return of blood to the ventricles stretch the cardiac muscles, which in turn promotes a more powerful contraction or systole. Hence, more blood is ejected. The stroke volume response to exercise is highly dependent on hydrostatic pressure effects. Stroke volume at rest in the erect position generally varies between 60 and 100 mL/beat among healthy adults, while maximum stroke volume approximates 100 to 120 mL/beat. When exercising in the erect position, stroke volume increases curvilinearly with the workload until it reaches a near-maximum value at approximately 50% of the individual's maximal aerobic capacity, increasing only slightly thereafter. Although it has been suggested that stroke volume may actually decrease at higher heart rates due to the disproportionate shortening in diastolic filling time, this issue remains unsettled.

Within physiologic limits, enhanced venous return increases the heart's end-diastolic volume, stretching cardiac muscle fibers and increasing their force of contraction. During exercise, there is an increase in stroke volume resulting from both the Frank-Starling mechanism and a decreased end-systolic volume. The latter is due to increased ventricular contractility, secondary to catecholamine-mediated sympathetic stimulation. However, it has been documented recently that the diastolic filling does not increase during ventricular filling. The Starling's law only explains the equality of the outputs of the left and the right ventricles. The increased stroke volume output during exercise is due to the extra volume of blood ejected during exercise from the ventricle, compared to about 40 to 50 percent of the total diastolic volume of blood ejected at rest. The stroke volumes of trained endurance athletes are considerably larger both at rest and during exercise than the untrained individuals. For untrained individuals, the cardiac output is increased by an increase in heart rate during the transition from rest to exercise, with only a small increase in stroke volume. However, for trained athletes increase in cardiac output is initiated by the augmentation of both heart rate and stroke volume. The cardiac profile of individuals who participate regularly in vigorous, isotonic exercise is characterized by left ventricular volume overload with increased left ventricular internal dimension, end-diastolic volume, stroke volume, and myocardial mass. These changes are associated with enhanced left ventricular performance and peripheral adaptations (e.g., increases in the size and number of skeletal muscle mitochondria, myoglobin content, oxidative enzymes, and capillary density) that facilitate a significantly higher aerobic capacity. **William E. Garrett, Jr., and Donald T. Kirkendall. Lippincott Williams & Wilkins, Philadelphia (2000).**

The increased aerobic capacity in the athlete appears to be primarily the result of increased maximal cardiac output, due to a greater increment in heart rate and, to lesser extent, stroke volume, rather than an increased peripheral extraction of oxygen. Because there is little variation in maximal heart rate and maximal systemic arteriovenous oxygen difference with training. $Vo_2$ max virtually defines the pumping capacity of the heart. Therefore, it is of major importance in the cardiovascular evaluation of the athlete. Most world-class endurance athletes have a $Vo_2$ max greater than 70 mL/kg/min, whereas many other championship athletes demonstrate values between 60 and 70 mL/kg/min. In contrast, the reported $Vo_2$ max of national-class bodybuilders and of professional football, tennis, and basketball players is between 40 and 50 mL/kg/min. Although intense physical training may increase the $Vo_2$ max by 25% or more, it has become: increasingly apparent that natural endowment rather than training per session, plays a major role in producing world-class endurance athletes.

Elite female long-distance runners typically exhibit a significantly lower resting heart rate due to the increased efficiency of their cardiovascular system. The heart pumps more blood per beat (increased stroke volume), meaning fewer beats are needed to maintain circulation at rest. This condition, known as athletic bradycardia, is common among long-distance runners and indicates an adaptation to prolonged aerobic training. Elite female middle-distance runners also experience a lower resting heart rate, though it may not be as pronounced as in long-distance runners. Their training involves both aerobic and anaerobic components, leading to cardiovascular efficiency improvements. Increased stroke volume contributes to a lower resting heart rate, though the balance between aerobic and anaerobic training influences the degree of this reduction. **Ehsani, A. A., Hagberg, J. M., Hickson, R. C., & Holloszy, J. O. (1978).**

Elite female weightlifters may experience a slight reduction in resting heart rate, but the effect is typically less significant compared to endurance athletes. While strength training does improve cardiovascular health to some extent, it primarily enhances muscular strength and power rather than significantly lowering resting heart rate. The lower emphasis on sustained aerobic exercise results in less pronounced cardiovascular adaptations that affect resting heart rate. Elite female weightlifters may experience a slight increase in stroke volume at rest. The effect is generally less pronounced compared to endurance athletes. Strength training results in increased myocardial thickness and contractility, but these changes do not lead to as significant an increase in stroke volume as seen with endurance training. The focus on anaerobic and strength training means less pronounced cardiovascular adaptations affecting stroke volume. **Fleck, S. J., & Dean, L. S. (1987).**

Elite female long-distance runners typically exhibit significantly increased stroke volume at rest. This is due to the heart's adaptations to prolonged aerobic training. Endurance training leads to an increase in the size of the left ventricle, which allows the heart to pump more blood per beat. Greater blood volume and improved ventricular filling contribute to the higher stroke volume. **Fleg, J. L., & Lakatta, E. G. (1988).** Elite female middle-distance runners show a moderate increase in stroke volume at rest. This increase is significant but not as pronounced as in long-distance runners due to a mix of aerobic and anaerobic training. Training for middle-distance events results in adaptations that enhance both aerobic capacity and anaerobic power, contributing to a higher stroke volume. Improved cardiac efficiency from training leads to better ventricular filling and stronger contractions. **Pluim, B. M., Zwinderman, A. H., van der Laarse, A., & van der Wall, E. E. (2000).**

## METHODOLOGY:

The primary purpose of this study is to conduct an imperative analysis on the interactions of heart rate at rest and stroke volume at rest among elite women. To fulfil the goals of the investigation, 45 (N=45) female elite national varsity athletes were randomly chosen to be subjects in groups of fifteen each, Group I- fifteen athletes (N=15) from long distance running group (5000/10000 mts race) Aerobic. Group II–fifteen athletes (N=15) from middle distance running group (800/1500 mts race) Aerobic and Anaerobic. Group III-fifteen athletes (N=15) weight lifting group (any weight category) Anaerobic, age of 18 to 22 years and all the athletes were in top form. The investigator informed to all volunteered elite athletes about the requirements of the study, and they all agreed to participate in the testing procedure. Volunteered subjects were in good health and trained by their coaches, and they have the national level playing experience and the sports age is between 7 and 9 years. Since the test was non-invasive, no ethical committee authorization was required. Participants in the specified test engaged in lively participation. The efficacy of hemodynamic system is essentially needed by athletes in three different sports in order to excel in competitive sports. Every sport has specific cardiovascular indices and exigencies for elite performance, in the same way better heart rate at rest and stroke volume at rest are needed. One of the study's limitations is that the subjects' social, economic, or cultural backgrounds were not taken into consideration. This study includes assessments of the heart rate at rest and stroke volume at rest among female elite athletes by using M-Mode Doppler Echo Cardiography.

## STATISTICAL ANALYSIS:

SPSS v25 and Microsoft Excel were used to analyze the data. The quantitative variables were analyzed by Using ANOVA; the numerical data on physical parameters from each of the three experimental groups were statistically analyzed to look for any suggestive variance. The whole data set was analyzed by using 25 version of the Indian Business Management Statistical Package for Social Sciences. The degree of conviction for purport was set at 0.05. The data is given below for analysis on criterion variables. When the F-Ratio is significant, the Scheffe's post hock test was used to find the paired mean significant difference, if any, among the groups of parameters separately.

**TABLE -I**
**Analysis of variance for the heart rate at rest of long distance running, middle distance running and weight lifting groups.**

| Test | Long Distance Running | Middle Distance Running | Weight lifting | Source of Variance | df | Sum of Square | Mean Square | Obtained 'F' Ratio | Table 'F' Ratio |
|---|---|---|---|---|---|---|---|---|---|
| $\bar{X}$ | 48.733 | 52.600 | 56.733 | B: | 2 | 480.178 | 240.089 | 269.158* | **5.168** |
| σ | 0.883 | 1.121 | 0.798 | W: | 42 | 37.467 | 0.892 | | |

***Significant at 0.01 level of assurance.**

**The table value for purport at 0.01 level with df 2 and 42 is 5.168.**
The table I displays that the means of heart rate at rest of long distance running group, middle distance running group and weight lifting groups are 48.733, 52.600 and 56.733 b/min severally. The attained 'F' ratio of 269.158 is much greater than the table value of 5.168 for df 2 and 42 requisite for significant at 0.01 level.
The result of the study indicates that the significant difference exists among elite women athletes of three experimental groups on Heart rate at rest. To define the noteworthy variations among the means of three experimental groups, the Scheffe'S test was employed as post-hoc test and the outcomes were exhibited in Table I A.

**TABLE-I A**

**Scheffe's post hoc test for heart rate at rest on the mean difference between long distance running, middle distance running and weight lifting groups.**

| Long Distance Running | Middle Distance Running | Weight Lifting | Mean Difference | Confidence Interval Value |
|---|---|---|---|---|
| 48.733 | 52.600 | -- | 3.867* | 1.360 |
| 48.733 | -- | 56.733 | 8.0* | 1.360 |
| -- | 52.600 | 56.733 | 4.133* | 1.360 |

***Significant at 0.01 level of assurance.**
The Table IA displayed the test mean difference on Heart rate at rest among the elite women athletes of all three experimental groups are 3.867, 8.0 and 4.133 b/min respectively, which are higher than that of confidence interval value 1.360 at 0.01 level of assurance. Hence, it is concluded from the results that the noteworthy difference existed among three experimental groups on Heart rate at rest. From the results it was concluded that, long distance running group has increased the Heart rate at rest as compared to the middle distance running group and weight lifting group. Further, it is concluded that highest mean difference existed between long distance

running and weight lifting groups. The test mean values on Heart rate at rest of three experimental groups are graphically exhibited in Figure I.

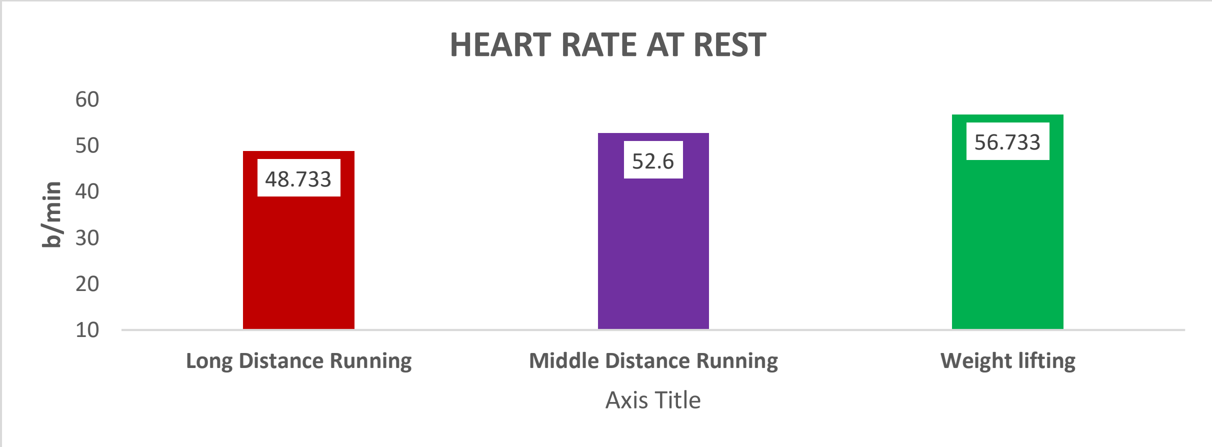


**FIGURE II: Bar graph on heart rate at rest means of long distance running, middle distance running and weight lifting groups.**

**TABLE -II**
**Analysis of variance for the stroke volume at rest of long distance running, middle distance running and weight lifting groups.**

| Test | Long Distance Running | Middle Distance Running | Weight lifting | Source of Variance | df | Sum of Square | Mean Square | Obtained 'F' Ratio | Table 'F' Ratio |
|---|---|---|---|---|---|---|---|---|---|
| $\overline{X}$ | 100.867 | 91.400 | 83.067 | B: | 2 | 2379.511 | 1189.756 | 319.740* | **5.168** |
| σ | 2.416 | 1.804 | 1.437 | W: | 42 | 156.267 | 3.721 | | |

***Significant at 0.01 level of assurance.**
**The table value for purport at 0.01 level with df 2 and 42 is 5.168.**
The table II displays that the means of stroke volume at rest of long distance running group, middle distance running group and weight lifting groups are 100.867, 91.400 and 83.067 ml/beat severally. The attained 'F' ratio of 319.740 is much greater than the table value of 5.168 for df 2 and 42 requisite for significant at 0.01 level.
The result of the study indicates that the significant difference exists among elite women athletes of experimental groups on Stroke volume at rest. To define the noteworthy variation among the means of three experimental groups, the Scheffe's test was employed as post-hoc test and the outcomes were portrayed in Table II A.

**TABLE-II A**

**Scheffe's post hoc test for stroke volume at rest on the mean difference between long distance running, middle distance running and weight lifting groups.**

| Long Distance Running | Middle Distance Running | Weight Lifting | Mean Difference | Confidence Interval Value |
|---|---|---|---|---|
| 100.867 | 91.400 | -- | 9.467* | 2.779 |
| 100.867 | -- | 83.067 | 17.8* | 2.779 |
| -- | 91.400 | 83.067 | 8.333* | 2.779 |

***Significant at 0.01 level of assurance.**
The Table II A displayed the test mean difference on Stroke volume at rest among the elite women athletes of all three experimental groups are 9.467, 17.8 and 8.333 ml/beat respectively, which are higher than that of confidence interval value 2.779 at 0.01 level of assurance. Hence, it is concluded from the results that the noteworthy difference existed among three experimental groups on Stroke volume at rest. From the results it was concluded that, long distance running has increased the Stroke volume at rest as compared to the middle distance running group and weight lifting group. Further it is concluded that highest mean difference existed between long distance running and weight lifting groups. The test mean values on the Stroke volume at rest of three experimental groups are graphically depicted in Figure II.

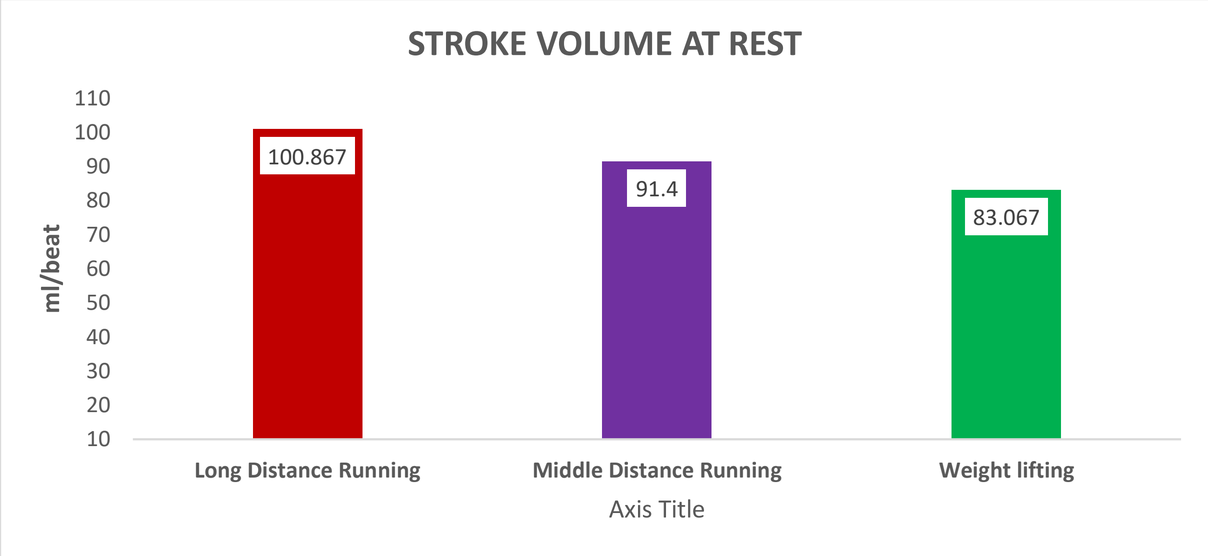


**FIGURE II: Bar graph on stroke volume at rest means of long distance running, middle distance running and weight lifting groups.**

## DISCUSSION:

The results of the study shows that specific physical demands in the form of long distance running, middle distance running and weight lifting exigencies cause a significant change in selected cardiovascular parameters. Based on the findings, it is concluded that the significant difference existed among the three experimental groups and emphatic impact was made on heart rate at rest and stroke volume at rest as compared to the normal reference values. Further, it indicates that the heart rate at rest of long distance running group has better adaptability by lowering and by increasing stroke volume than that of other experimental groups.

In this study, the researcher explains that there would be a significantly lower heart rate at rest and significantly higher stroke volume at rest which is proved by the research evidence that is clinically relevant to the present study.

## CONCLUSION AND IMPLICATION:

The subsequent completions were inferred from the investigation's findings.

Based on the puzzling out of the investigation the investigator implied that the heart better adaptability through lower heart rate at rest and higher stroke volume at rest is significantly influenced by long distance running group, as compared with other two experimental groups. Based on the above discovered facts chronic long distance running group is good for developing grater interactions between heart rate at rest and stroke volume at rest among elite women.

## CONFLICT OF INTEREST: No

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