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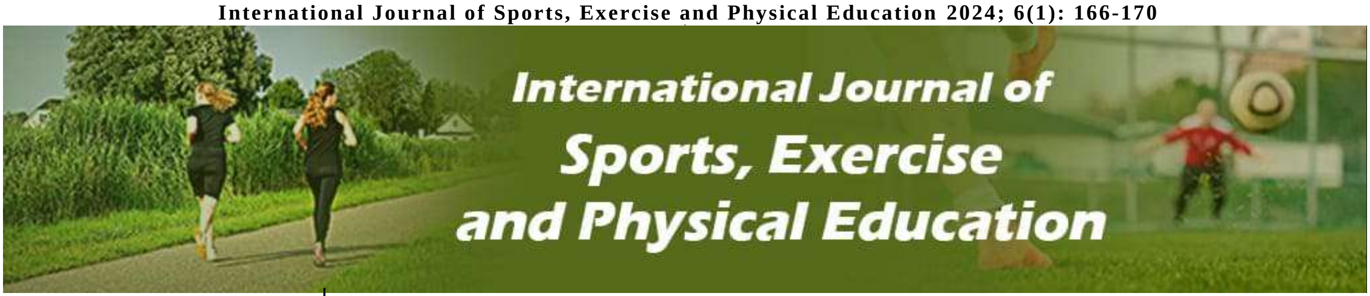

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A scientific analysis on the impact of long distance running and middle distance running on cardiac functions of women elite athletes

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Abstract
A planned, systematic and chronic training regimen will always leads to significant adaptations on cardiac functions. The heart is an involuntary organ which directly get impact by any systematic training protocol as compared to any other organ of the body, based on this the investigator is focusing on how a long distance runners and middle distance runners training protocol leads to a favorable impact on selected cardiac functional parameters. To meet the purpose the investigator has chosen (N=30) women volunteered elite athletes of each (N=15) of long distance running and middle distance running athletes between 18 to 22 years. All the volunteered elite athletes are trained by their coaches for about 7 to 9 years. The selected criterian parameters are Heart Rate at rest (HR), Stroke Volume at rest (SV), and Cardiac output at rest ($\dot{Q}$), and they were measure by M-Mode Doppler Echocardiography with the support of qualified cardiologist. The level of significant is set at 0.05 level of assurance. The study concluded that a regular and systematic long and middle distance runners training significantly brought changes in selected variables as compared to the normal, healthy, and untrained women. Further, it is concluded that long distance running have significantly lowered heart rate at rest, and significantly enhanced stroke volume at rest and cardiac output at rest as compared to the middle distance running group. In ordered to find out the significant difference analysis of variance (ANOVA) is employed.

Keywords: Long distance runners, middle distance runners, heart rate at rest, stroke volume at rest, cardiac output at rest

Introduction
Excellently fit individuals may have resting heart rates between 50 and 60 bpm, while very skilled athletes may have resting heart rates as low as 50 bpm. Normal stroke volume values for a resting healthy individual would be approximately 60-100mL. Elite women athletes with improved heart rate and stroke volume will certainly show a greater cardiac output. Extraordinary training is frequently linked to morphological alterations in the heart, such as larger, thicker, and more massified left ventricle. Athlete's heart refers to the increase in left ventricular mass that occurs as a result of exercising, the athlete's heart can be divided into two distinct physical forms a heart trained for strength and an endurance-trained heart by Morganroth *et al.* Their idea states that athletes who participate in high-dynamic sports like running, develop primarily larger left ventricular chambers with correspondingly thicker walls due to volume overload brought on by the high cardiac output of endurance training. Hence, it is assumed that athletes with endurance training have eccentric left ventricular hypertrophy, which is defined by a constant relationship between the left ventricular wall. Despite recent research by a number of authors investigating the morphology of the athlete's heart and the effects of various sports on cardiac structure, differently and make athletes to work with different capabilities based on the natural law cause and effect. Hence, the investigator decided to concentrate on the fundamental types of exercise training such as long distance running and middle distance running. One of the most fascinating and traditional sports medicine study topics are related to the athlete's heart. Henschen (1899) [1] is credited with providing the earliest description of the athlete's heart and he is a pioneer investigator to reveal on athlete's heart.

Athlete's heart is a result of systematic training, and only competitive sports cause an athlete's heart to develop. This understanding of the phenomenon and the emergence of contemporary high performance athletes are not accidental. Other physical activities have been routinely claimed, including ones tied to one's employment. This is a true "athlete's heart," as Henschen puts it. Researchers have long engaged in a scientific tug-of-war over whether the athlete's heart is diseased or, at the very least, borderline pathological. The athlete's heart is seen as a physiologically adapted, incredibly effective, and healthy heart. Additionally, he used basic physical diagnostic methods to arrive at his conclusions. With meticulous percussion, the size of the heart was ascertained. Upon examining the subsequent, inaccurate, readings of the athlete's heart by writers with access to far more advanced instruments. This suggests that skiing induces an increase in the size of the heart, and that this larger heart. Percussion was used with great care to determine the heart's size. It may be useful to quote Henschen (1899) [1] when examining the inaccurate later interpretations of the athlete's heart by writers who had access to far more advanced instruments. It follows that skiing causes the heart to enlarge and that this enlarged heart is capable of doing more work than a normal heart. As a result, an athlete's heart is a physiological expansion of the heart brought on by physical exercise. Despite this clever interpretation, athletes were taken into account in several later studies. As a result of the athlete's heart expanding in response to repeated exercise stimuli, their maximal stroke volume and cardiac output adaptations rise. Since training has no effect on maximal heart rate, this increases oxygen supply in the trained state. For professional athletes, it serves as a standard. Haykowsky, Mark J. *et al.* (2018) [2]. Exercises that are systematic and routine will alter the body's many systems. Training leads to both improved performance and increased fitness levels, thus such modifications might be advantageous to individuals who get it. At rest, cardiac output is roughly 5 L/min; during dynamic exercise, cardiac output increases by 5 to 6 L/min for every 1 L/min increase in oxygen intake. An increase in heart rate and stroke volume is the cause of the rise in cardiac output. The chosen subject sports activities long and middle distance runs also significantly lower the heart rate, and increase stroke volume, accordingly it enhance cardiac output.

$$\dot{Q} = \text{HR} \times \text{SV}$$

Where cardiac output is the product of heart rate and stroke volume.

Typically, girls and women who are usually active attain their maximum cardiac output of 20 to 25 liters per minute, but endurance-trained athletes can reach up to 40 liters per minute. At rest, heart rates typically range from 60 to 70 beats per minute; with oxygen uptake, these rates rise linearly to a maximum of 190 to 200 beats per minute. Most people agree that the withdrawal of vagal effects on heart rate regulation is mostly responsible for the initial spike in heart rate (Up to 100 beats per minute). Additional sympathetic drive accompanied by a reduction in vagal activity. Further increases in sympathetic impact on the heart rate result in heart rate alterations of more than 150 beats per minute to maximal heart rate.

In women who are typically active, the stroke volume is about 70 to 80 milliliters per beat at rest; for athletes with endurance training, this can reach 130 to 150 milliliters per beat. The average fit individual's stroke volume increases at the beginning of exercise and keeps increasing until a value of 120 to 140 ml/beat is reached at 40% to 50% of the maximal oxygen intake. In contrast, new research indicates that stroke volume can gradually rise in endurance-trained athletes until VO2 max is reached, reaching a value of 200-220 ml/beat.

Methodology

To fulfill the study's objectives, the primary goal of this inquiry was to determine how cardiovascular factors varied across elite female athletes. The subjects were 30 healthy female varsity national medal winners and they are again subdivided into two groups of each 15 subjects of their specific sports activity. Group I consisted of fifteen athletes (N =15) from long distance running (5000/10000 meters) Aerobic. Group II fifteen participants (N=15) from the middle distance running (800/1500 meters) combination of both Aerobic and Anaerobic. Between the ages of 18 and 22, each athlete was at the peak of their abilities. Following their disclosure of the study's conditions, all of the chosen elite athletes consented to take part in the testing process. Every participant was in excellent health, received coaching from their coaches, participated in national competitions, and sports age ranged from 7 to 9 years. There was no need for ethical committee approval, because the investigation was completely non-invasive, and every subject eagerly took part in the essential exam. In order to succeed in competitive sports and activities, the cardiovascular system function well. With the fundamental parameters such as Heart rate at rest (HR), Stroke volume at rest (SV) and Cardiac output at rest ($\dot{Q}$).

Scharf, Michael *et al.* (2010). The efficiency of the cardiovascular system is essential for success in sports and other competitive activities. Coaches, personal fitness instructors, and athletes who derive advantages from many training modalities and strategies consistently alternate between the most effective ones or integrate multiple training approaches to optimize outcomes and meet athletic objectives. Athletes may have low resting heart rates in comparison to the general population. Heart rate is frequently utilized in sports as a gauge of exercise intensity. The "individual aerobic threshold" is the heart rate. In endurance and team sports, training put an impact on heart rate variability during rest and after exercise. Training results in an increased vagally associated heart rate variability indices at rest, which enhances exercise performance. Nummela *et al.* (2010) [4]. Sprinters can benefit from heart rate variability by understanding the potential for training-related changes. Abad, Cesar, and others (2017).

It is customary to use heart rate as an anchor point for training recommendations derived from performance evaluation. There's a need for precise data on the relationship between HR and objective exercise intensity because heart rate is often utilized as a mediator between results from laboratory tests and regular training activities. This held true for leisure and endurance sports. Heart rate and stroke volume are the two factors that influence cardiovascular function. To identify alterations brought on by aging and training intensity, precise assessments of the cardiac output and stroke volume during exercise are essential. The term "stroke volume" describes the amount of blood expelled from the left or right ventricle every beat. It ranges from roughly 1000 mL (2-2.5 mL/kg) at rest to 1700 mL (3-4 mL/kg) or more at maximal exertion. When exercise commences, stroke volume rises sharply to a maximum heart rate of approximately 40%. Fundamentally speaking, heart rate (HR) indicates the number of beats per minute, but cardiac output (CO), which is the product of heart rate and stroke volume (SV), denotes the total volume of blood pumped by the ventricle. The three are frequently written as CO= HR x SV. An adult's resting heart rate can range from 60 to 80 beats per minute, with the average adult's stroke volume at rest in a standing position being between 60 and 80 milliliters. Consequently, the average cardiac output at rest is 4.8-6.4 liters per minute. However, these figures do not apply to athletes; rather, they apply to the typical individual elite competitors. Resting heart rates in elite athletes have been reported to be as low as 28 to 40 beats per minute, which translates into significantly increase cardiac output.

Outcome measure

The present investigation is done on the scientific analysis on cardiovascular responses in relation to long distance and middle distance runners. On the Doppler echo cardiograph table, the subjects were placed in a left side lateral position. The transducer was positioned across the subject's chest. The ultrasonic impulse transmitter and receiver are simultaneously located on the left side of the intercostal parasternal area on the inside of the chest wall. First, the left ventricle and subsequently the chest wall were exposed to ultrasonic radiation. The ultrasonography path first entered the right ventricle, then passed into the left ventricle's chamber, and ultimately arrived at the posterior heart wall, where it met the intraventricular septum (IVS). The echo curves that were displayed on the screen could be photographed.

Statistical analysis

SPSS v25 and Microsoft Excel were used to analyze the data. The quantitative variables were subjected to mean and standard deviation (SD) by Using ANOVA, the numerical data on specific cardiovascular parameters from each of the two experimental groups were statistically analyzed to look for any suggestive variance. The whole dataset was analyzed by using version 25 of the Indian Business Management Statistical Package for Social Sciences. The degree of conviction for purport was set at 0.05 due to the small number of participants. The selected criterion may change as a result of many outside stimuli. The data is given below for analysis on criterion variables.

Table 1: Analysis of variance for the heart rate at rest of long distance runners and middle distance runners group.

Test	Long Distance Runners	Middle Distance Runners	Source of Variance	DF	Sum of Squares	Mean Squares	Obtained 'F' Ratio	Table 'F' Ratio
$\bar{X}$	48.600	58.067	B:	1	672.133	672.133	442.484*	4.196
σ	1.121	1.334	W:	28	42.533	1.519		

*Significant at 0.05 level of assurance
The table value for purport at 0.05 levels with df 1 and 28 is 4.196

Table 1 shows the means of long distance runners group and middle distance runners group 48.600 and 58.067 beats per minute. The attained "F" ratio of 442.484 is much higher than the table value of 4.196 for df 1 and 28, which is required for significance at 0.05 level of assurance.

The study's findings suggest that there is a noteworthy variation in heart rate at rest between the long distance and middle distance runners group. Further, it is concluded that there is a significant difference observed in between long distance runners group and middle distance runners group of heart rate at rest in favour of long distance runners group. The mean values are depicted in figure-1.

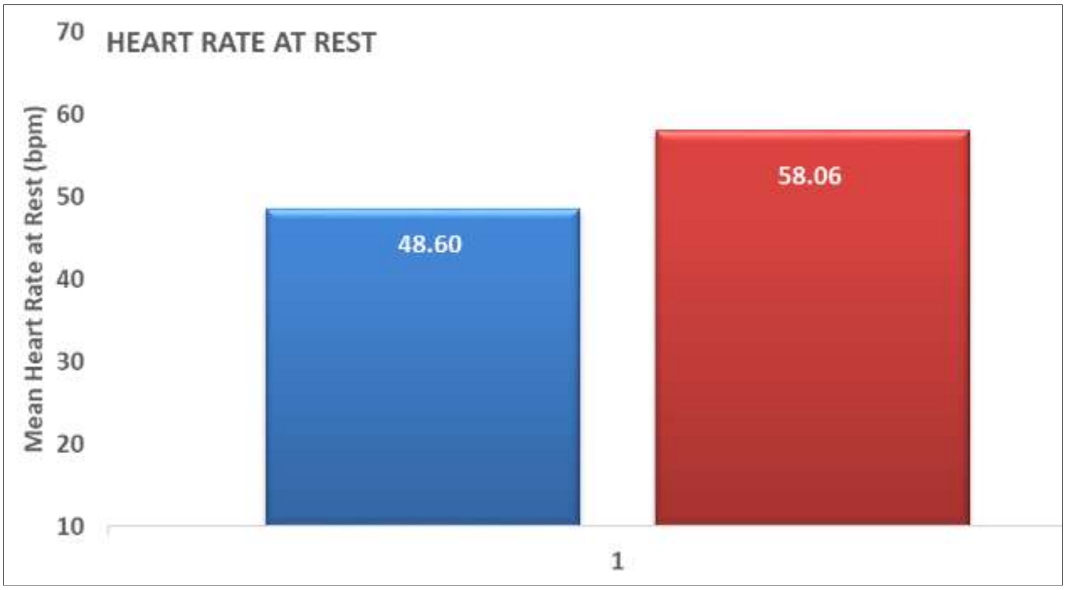

Fig 1: Bar chart on heart rate at rest means of long distance runners and middle distance runners group

Table 2: Analysis of variance for the stroke volume at rest of long distance runners and middle distance runners group

Test	Long Distance Runners	Middle Distance Runners	Source of Variance	DF	Sum of Squares	Mean Squares	Obtained 'F' Ratio	Table 'F' Ratio
$\bar{X}$	100.000	86.067	B:	1	1456.033	1456.033	187.924*	4.196
σ	3.464	1.870	W:	28	216.933	7.748		

*Significant at 0.05 level of assurance
The table value for purport at 0.05 level with df 1 and 28 is 4.196

Table 2 shows that the middle distance runners and long distance runners group respective means are 100.000 and 86.067 milliliters per beat. The obtained "F" Ratio of 187.924 is significantly much higher than that of 4.196 table value for df 1 and 28 which is needed to be considered as significant at 0.05 level of assurance.

The study's findings show that there is a considerable difference between long distance and middle distance runners on SV at rest by identify the significant variation between the means of the two experimental groups. Further, it is concluded that there is a significant difference observed in between long distance runners group and middle distance runners group on stroke volume at rest in favour of long distance runners group. A graphical depiction on the mean value of two groups are portrayed in figure-2.

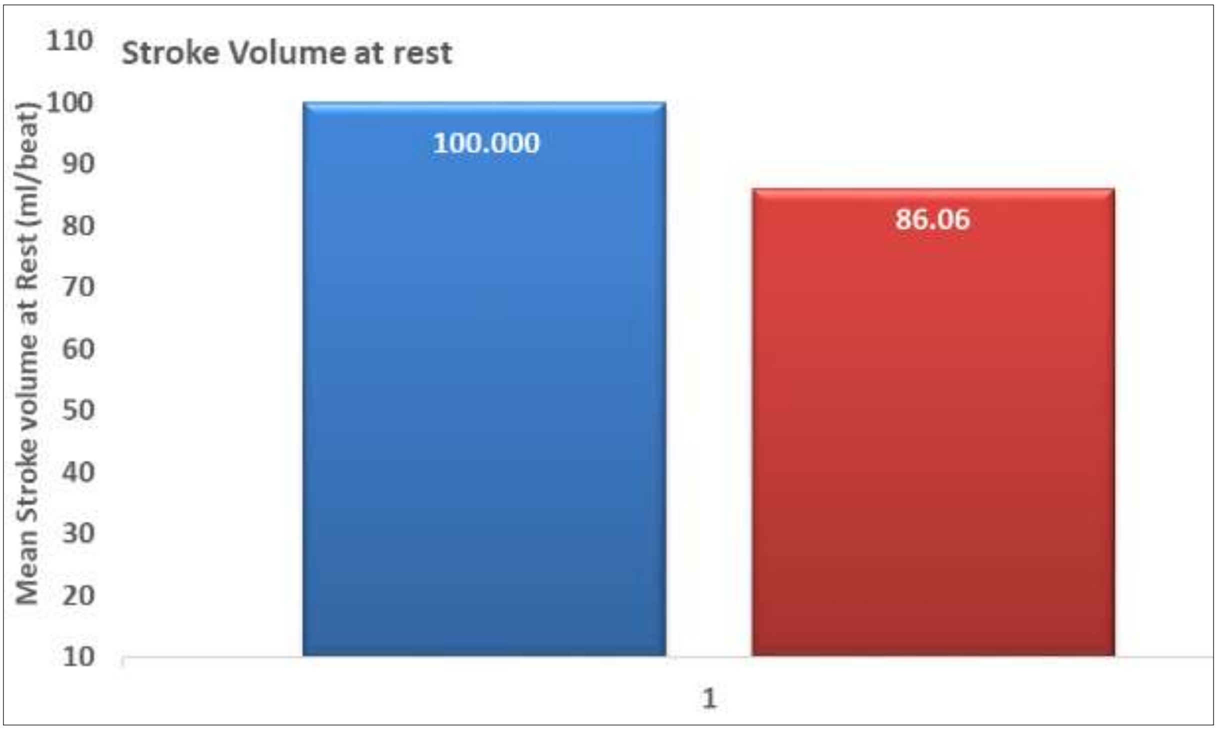

Fig 2: Bar chart on stroke volume at rest means of long distance runners and middle-distance runners group

Table 3: Analysis of variance for the cardiac output of long distance runners, and middle distance runners group

Test	Long Distance Runners	Middle Distance Runners	Source of Variance	Df	Sum Of Squares	Mean Squares	Obtained 'F' Ratio	Table 'F' Ratio
$\bar{X}$	4933.067	4640.933	B:	1	640064.133	640064.133	350.050*	4.196
σ	50.369	33.465	W:	28	51197.867	1828.495		

*Significant at 0.05 level of assurance
The table value for purport at 0.05 level with df 1 and 28 is 4.196

Table 3 shows that the long distance runners, and middle-distance runners groups have the respective averages of 4933.067 and 4640.933 milliliters per minute. The obtained "F" ratio of 350.050 is significantly higher than the 4.196 table value for df 1 and 28, which is required to be significant at the 0.05 level. The study findings show that there is a considerable difference in cardiac output at rest between the experimental groups. Further, it is concluded that the cardiac output of long distance runners group is better than the middle distance runners group. The means value of cardiac output are illustrated in Figure-3.

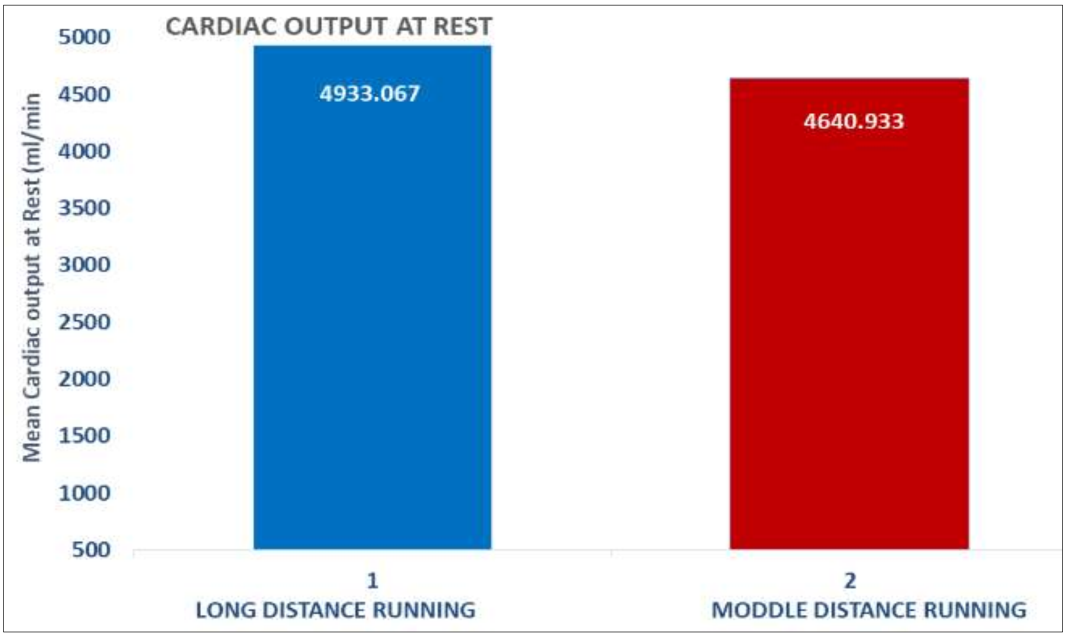

Fig 3: Bar chart on cardiac output at rest means of long distance runners and middle distance runners group

Discussion

The results of this study show that distinct categories of anaerobic and aerobic demands cause a significant variation in selected cardiovascular parameters. Based on the findings, there is a significant difference existed between the two experimental groups and a favorable influence on heart rate at rest, stroke volume at rest and cardiac output at rest as compared to the resting value of healthy untrained women. Further it indicates that long distance runners have better adaptability than that of middle distance runners. Limitations associated with the study includes no particular motivational strategies were employed during the testing process, which could have contributed to the performance differences caused by a lack of drive. The investigator did not make any attempt to monitor or evaluate the amount and caliber of food consumed on an individual basis, even though the subject resided at the hostel. The study's limitations included the possibility that variables including resting body position, exercise, and emotional fluctuations could affect heart rate. The degree of physical effort, way of life, physiological stress, and other elements influencing metabolic processes were deemed to be constraints. No thought was given to the social, economic, or cultural backgrounds of the subjects. Only female elite athletes and cardiovascular measures are included in this study.

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

Conclusion and Implications

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

Heart rate at rest has been significantly reduced by long distance, Middle distance runners group but lowest heart rate was found with long distance runners group. Stroke Volume at rest has been significantly increased by two experimental group, however, higher improvement is in favor of long distance runners group as compared to middle distance runners. cardiac output at rest has been significantly increased by two experimental groups however, it concluded that higher improvement are in favor of long distance runners group as compared to middle distance runners group. Compared to other physical activities, long distance running is highly advised to produce a noticeable adaptation in heart rate, stroke volume, and cardiac output.

Conflict of Interest: No.

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