International Journal of Physiology, Health and Physical Education 2025; 7(2): 85-88

ISSN Print: 2664-7265
ISSN Online: 2664-7273
Impact Factor: RJIF 8
IJPHPE 2025; 7(2): 85-88
www.physiologyjournals.com
Received: 06-07-2025
Accepted: 10-08-2025

Dr. Arvind Malik
Professor, Department of Physical Education, Kurukshetra University, Kurukshetra, Haryana, India

Rajat Chauhan
Research Scholar, Department of Physical Education, Kurukshetra University, Kurukshetra, Haryana, India

Corresponding Author:
Dr. Arvind Malik
Professor, Department of Physical Education, Kurukshetra University, Kurukshetra, Haryana, India

Investigation of Stroke Volume and Total Peripheral Resistance Across Sports Disciplines and Sedentary Individuals

Arvind Malik and Rajat Chauhan

DOI: https://doi.org/10.33545/26647265.2025.v7.i2b.127

Abstract
The objective of this study was to examine the differences in cardio-functional parameters specifically: Total Peripheral Resistance (TPR) and Stroke Volume (SV) among elite athletes from various sports disciplines and non-athletes.
Methodology: A total of 160 male participants aged 18–25 were included: 130 elite athletes (who had secured at least first, second, or third positions at inter-university or national-level competitions) and 30 non-athletes. The athletes were categorized into six groups: long-distance runners (n=20), volleyball (n=20), basketball (n=20), football (n=20), hockey (n=20), and yoga practitioners (n=30). Cardio-functional measurements were obtained using the Cheetah Cardiac Output Monitor (COM), a non-invasive bio-reactance-based device developed by Cheetah Nicom, Israel.
Results: Analysis of variance (ANOVA) revealed statistically significant differences in TPR and SV across the different groups, with F-values of 21.25 and 86.80 ($p<0.01$), respectively. Post hoc t-test comparisons demonstrated that long-distance runners had significantly lower TPR and higher SV compared to basketball, football, hockey, yoga, and non-athlete groups ($p<0.05$), but not significantly different from volleyball players in terms of TPR. Furthermore, stroke volume was significantly higher in long-distance runners than in all other groups ($p<0.01$). The findings indicate that long-distance runners exhibit superior vascular compliance and cardiac efficiency, as reflected by reduced TPR and elevated SV. Conversely, non-athletes displayed the least favorable cardio-functional profiles.
Conclusion: The study concludes that regular participation in sustained aerobic activities leads to more efficient cardiovascular adaptations compared to anaerobic or non-athletic lifestyles.

Keywords: Cardio-Functional parameter, Total Peripheral Resistance (TPR), Stroke Volume (SV), Cardiovascular Efficiency and Aerobic Adaptation

Introduction

Cardiovascular diseases (CVDs) are the leading cause of mortality globally, accounting for approximately 17.9 million deaths annually, or 32% of all global deaths [1]. Of these, 85% result from heart attacks and strokes. Over three-quarters of these deaths occur in low and middle income countries. Among the 17 million premature deaths (under the age of 70) attributed to noncommunicable diseases (NCDs), 38% are caused by CVDs [1].
Cardiovascular efficiency is a fundamental determinant of athletic performance and general health [2, 3]. The effectiveness of the cardiovascular system in supplying oxygen and nutrients to active musculature depends on several physiological parameters [4]. Among these, Total Peripheral Resistance (TPR) and Stroke Volume (SV) are critical markers of circulatory competence and cardiac workload. These indicators reflect the dynamic adaptability of the cardiovascular system in response to various physical activity patterns and training intensities.
Endurance-based training—common in sports such as long-distance running—primarily engages aerobic pathways, leading to notable cardiovascular adaptations such as bradycardia, increased stroke volume, and decreased TPR [2, 3]. In contrast, sports involving intermittent high-intensity exertion (e.g., football, basketball) or sustained isometric practices (e.g., yoga) generate different hemodynamic responses. TPR refers to the resistance encountered by blood in systemic circulation and is influenced by arteriolar diameter, blood viscosity, and vascular tone, regulated via both neural and hormonal mechanisms [4, 5].

In addition to physical activity, cardiovascular disease is also modulated by various controllable and uncontrollable risk factors. Modifiable factors include smoking, diet, alcohol consumption, elevated cholesterol levels, diabetes, obesity, and physical inactivity, while non-modifiable factors encompass age, gender, and genetics. According to the National NCD Monitoring Survey (2017–18), 41.4% of Indian adults (ages 18–69) fail to meet the WHO's physical activity guidelines of at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity activity per week [6]. The ICMR-INDIAB Phase 1 Study reported an even higher prevalence of inactivity, with 54.4% of adults being inactive and only 13.7% classified as highly active [7].

Regular endurance training significantly enhances stroke volume at rest and during exertion. Adaptations include increased chamber size, enhanced myocardial compliance, elevated preload, and improved contractility [3, 2]. Consequently, a greater blood volume is pumped per beat, improving cardiac output efficiency without increasing heart rate. Trained runners have been found to exhibit 25–30% higher stroke volume both at rest and during submaximal activity compared to sedentary individuals [8, 5].

Furthermore, TPR serves as a robust indicator of vascular health. Lower TPR values are associated with improved arterial compliance, enhanced endothelial function, and reduced cardiac afterload all of which are observed in individuals regularly participating in aerobic training [4, 5, 2]. These adaptations collectively promote greater cardiovascular efficiency and reduced disease risk in physically active individuals.

Understanding how different sports disciplines influence cardio-functional parameters is vital for enhancing performance and preventing cardiovascular risks. Despite known health benefits of exercise, limited research compares sport-specific effects on Total Peripheral Resistance and Stroke Volume. This study addresses that gap, offering insights for athletic training and cardiovascular health promotion.

Materials and Methods

This cross-sectional analytical study included 160 male participants aged 18 to 25 years, comprising 130 elite sportsmen and 30 non-sportsmen. The elite athletes were purposively selected based on their documented performance securing first, second, or third positions in inter-university or national-level competitions during the study period. The participants were grouped according to the nature of their sports discipline as follows: Long-distance runners (n = 20), Volleyball players (n = 20), Basketball players (n = 20), Football players (n = 20), Yoga practitioners (n = 30), Hockey players (n = 20), and a Control group of non-sportsmen (n = 30).

- **Sampling Method:** A purposive sampling technique was employed to ensure inclusion of high-performance athletes who met predefined eligibility criteria, while the non-sportsmen were randomly selected from college students with no history of formal sports training or competitive participation.
- **Measurement Tools:** Cardio-functional parameters Total Peripheral Resistance (TPR) and Stroke Volume (SV) were measured using the Cheetah Cardiac Output Monitor (C.O.M.), a non-invasive hemodynamic monitoring device based on Bio-Reactance Technology developed by Cheetah Medical (Nicom, Israel), provides reliable and continuous measurement of cardiovascular indices and is widely validated in clinical and sports settings.
- **Ethical Considerations:** The study protocol was reviewed and approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants before data collection. All procedures complied with the ethical standards of the Declaration of Helsinki (2013 revision).
- **Statistical Analysis:** One-way Analysis of Variance (ANOVA) was employed to determine the differences in TPR and SV among the seven groups. Where significant differences were found, post hoc t-tests were conducted to identify inter-group variations. A significance level of $p < 0.05$ was used for all statistical tests.

Results

Table 1: Analysis of variance (ANOVA) for total peripheral resistance among sports person of various sports disciplines and non-sports persons.

Source of Variation	Sum of Squares	df	Mean Square Variance	F-Value
Between Groups	5900158.717	6	983359.786	21.251**
Within Group	7079725.683	153	46272.717	

** - Significant at 0.01 level

The analysis of variance (ANOVA) for Total Peripheral Resistance (TPR) (measured in Dyne/cm³) among athletes from various sports disciplines and non-sports persons revealed a statistically significant difference across the groups. The obtained F-value of 21.25 exceeds the critical value at the 0.01 level of significance, indicating that the differences in mean TPR among the groups are not due to chance. This confirms the presence of a significant variation both within and between the groups under investigation. In order to further examine the magnitude and direction of these differences, pairwise comparisons were conducted using independent t-tests.

Table 2: Significance of difference between means of long-distance runner and player of various sports discipline and non-sportsmen for total peripheral resistance.

Sport1	Sport2	Mean1	Mean2	M.D.	SD1	SD2	Significance	p-value	T-value
Long dist. Runner	Basketball	902.50	992.65	-90.15	123.85	180.14	No	0.07	-1.84
Long dist. Runner	Football	902.50	1,068.74	-166.24	123.85	160.99	Yes	0.00	-3.79**
Long dist. Runner	Hockey	902.50	1,062.65	-160.15	123.85	207.76	Yes	0.01	-2.96**
Long dist. Runner	Volleyball	902.50	890.95	11.55	123.85	130.80	No	0.78	0.29

Long dist. Runner	Yoga	902.50	1,205.13	-302.63	123.85	244.42	Yes	0.00	5.76**
Long dist. Runner	Non-sportsmen	902.50	1,449.63	-547.13	123.85	311.98	Yes	0.00	8.64**

** - Significant at 0.01 level

Further analysis using independent t-tests, as presented in Table 2, indicates that long-distance runners exhibited significantly lower mean Total Peripheral Resistance (TPR) (Dyne/cm³) compared to participants from most other groups. The t-values comparing long-distance runners with basketball, football, hockey, yoga, and non-sports persons were –1.84, –3.79, –2.96, 5.76, and 8.64, respectively, all of which suggest statistically significant differences ($p < 0.05$ or $p < 0.01$), except for the comparison with volleyball players (t = 0.29), which was not significant. These results underscore that long-distance running, as an endurance activity, is associated with more favorable vascular adaptations and reduced peripheral resistance compared to other athletic and sedentary profiles.

Table 3: Analysis of variance (ANOVA) for total peripheral resistance among sports person of various sports disciplines and non-sports persons

Source of Variation	Sum of Squares	df	Mean Square Variance	F-Value
Between Groups	130575.706	6	21762.618	86.802**
Within Group	38108.692	153	250.715	

** - Significant at 0.01 level

The analysis of variance (ANOVA) for Stroke Volume (SV) among athletes from various sports disciplines and non-sports persons revealed a highly significant difference across the groups. The computed F-value of 86.80 exceeds the critical value at the 0.01 level of significance, indicating that the variability in stroke volume among the different categories is statistically significant. This finding confirms the presence of substantial differences both within and between groups in terms of cardiovascular efficiency. To further explore the extent and direction of these differences, post hoc comparisons were conducted using independent t-tests.

Table 4: Significance of difference between means of long-distance runner and player of various sports discipline and non-sportsmen for stroke volume.

Sport1	Sport2	Mean1	Mean2	M.D.	SD1	SD2	Significance	p-value	T-value
Long Dist. Runner	basketball	152.99	136.11	16.89	10.62	25.10	Yes	0.01	2.77*
Long Dist. Runner	football	152.99	126.21	26.78	10.62	9.17	Yes	0.00	8.44**
Long Dist. Runner	hockey	152.99	114.80	38.19	10.62	23.54	Yes	0.00	6.61**
Long Dist. Runner	volleyball	152.99	126.17	26.82	10.62	17.61	Yes	0.00	5.83**
Long Dist. Runner	yoga	152.99	87.37	65.62	10.62	8.11	Yes	0.00	-23.44**
Long Dist. Runner	Non-Sportsmen	152.99	67.54	85.45	10.62	11.97	Yes	0.00	-26.48**

** - Significant at 0.01 level and * - Significant at 0.05 level

Further analysis using independent t-tests, as shown in Table 4, revealed that long-distance runners demonstrated significantly higher mean Stroke Volume (ml) compared to all other groups. The t-values for comparisons with basketball, football, hockey, volleyball, yoga, and non-sports persons were 2.77, 8.44*, 6.61**, 5.78**, –23.44**, and –26.48**, respectively ($p < 0.05$ or $p < 0.01$). These results indicate that long-distance runners possess superior cardiac efficiency, as evidenced by elevated stroke volume, likely due to chronic aerobic training adaptations. The negative t-values for yoga practitioners and non-sports persons further underscore the stark contrast between endurance-trained individuals and those with low or non-aerobic physical activity profiles.

Discussion of Results

As shown in Table 1, the one-way ANOVA for Total Peripheral Resistance (TPR) revealed a statistically significant group effect, $F(6, 153) = 21.25$, $p<.01$, indicating considerable differences in vascular resistance among long-distance runners, team-sport athletes, and non-sports persons. Subsequent pairwise t-tests (see Table 2) demonstrated that long-distance runners had significantly lower mean TPR than football (t = –3.79), hockey (t = –2.96), yoga (t = 5.76), and non-sports individuals (t = 8.64). However, the difference compared to volleyball players (t = –1.84) and basketball players (t = 0.29) was not statistically significant. These findings indicate that endurance training, as seen in long-distance runners, leads to improved vascular compliance and reduced resistance in systemic circulation.

Regarding Stroke Volume (SV), Table 3 shows that the ANOVA yielded a highly significant result, $F(6, 153) = 86.80$, $p<.01$, confirming substantial differences among the groups. As reported in Table 4, long-distance runners exhibited significantly higher mean stroke volume compared to basketball (t = 2.77, $p<.05$), football (t = 8.44, $p<.01$), hockey (t = 6.61, $p<.01$), volleyball (t = 5.78, $p<.01$), yoga (t = –23.44, $p<.01$), and non-sports persons (t = –26.48, $p<.01$). These results support prior research indicating that endurance athletes demonstrate greater cardiac output due to increased ventricular compliance, enhanced myocardial contractility, and larger blood volume [9, 10].

As per the results, long-distance runners demonstrated significantly superior cardio-functional parameters specifically, stroke volume (SV) and total peripheral resistance (TPR) when compared to athletes from other sports disciplines such as volleyball, basketball, hockey, football, and non-sports persons. This reinforces the critical role of physical training and aerobic conditioning in cardiovascular adaptations. Endurance athletes, including long-distance runners and cyclists, consistently exhibit lower resting TPR, attributed to chronic exposure to elevated cardiac output and sustained vasodilation, which in turn lead to structural and functional vascular adaptations [9, 10]. In contrast, athletes involved in intermittent or static sports, such as football or weightlifting, typically display less pronounced reductions in TPR due to the shorter duration and lower cumulative vascular demand of these activities [11].

Stroke volume (SV) refers to the volume of blood ejected by the left ventricle during each cardiac cycle. It is modulated by three primary factors: preload (end-diastolic volume), afterload (vascular resistance), and myocardial contractility. Aerobic training significantly increases SV both at rest and during exertion through physiological changes such as enhanced ventricular compliance, increased plasma volume, and improved myocardial efficiency [12, 10]. As seen in this study, long-distance runners demonstrated higher SV values than athletes from anaerobic or skill-based disciplines. This observation aligns with prior studies, which report that endurance-trained athletes exhibit larger stroke volume and cardiac output as part of the adaptive phenomenon known as the "athlete's heart" [9, 11].

Athletes involved in intermittent activities, such as football and basketball, often exhibit moderate improvements in SV due to variable cardiovascular stress profiles [13]. Conversely, non-sportspersons presented the least favorable cardiovascular efficiency, further affirming that a sedentary lifestyle is linked with increased TPR and diminished cardiac function [14, 15]. The autonomic nervous system (ANS) also plays a critical role in regulating heart rate (HR) before, during, and after exercise, offering insights into training load, recovery, and overall cardiovascular resilience [13].

Total Peripheral Resistance is an essential indicator of systemic vascular resistance. Lower TPR levels, as observed in endurance athletes, suggest enhanced arterial elasticity and vasodilatory capacity, which collectively reduce cardiac workload [9]. These values, when considered alongside elevated stroke volume, reflect a highly efficient and adaptive cardiovascular system.

Furthermore, VO_2 max, a direct measure of aerobic capacity, is strongly influenced by cardiac output, particularly stroke volume, rather than solely by muscular oxygen utilization. This underlines the heart's pivotal role in determining endurance performance [12]. Inactivity, on the other hand, reverses many of the cardiovascular benefits gained through training, emphasizing the need for continuous physical engagement [14, 9].

The concept of the "athlete's heart"—a benign and reversible enlargement of the heart muscle in response to prolonged training—should not be mistaken for pathological changes, provided it remains within physiological boundaries [9, 11]. Notably, Masters athletes have demonstrated that high levels of cardiovascular function can be maintained well into older age through sustained aerobic training [15]. Finally, research shows that maximum heart rate is not a fixed, age-dependent value but may be modulated through endurance training and tapering [14].

Conclusion

This study highlights that aerobic and long-duration physical activity significantly enhances stroke volume and reduces total peripheral resistance. Long-distance runners showed superior cardio-functional parameters compared to other athletes and non-sports persons. The findings confirm the positive impact of endurance training on cardiovascular efficiency. Additionally, age, diet, and regular physical activity influence these parameters. These insights may aid in the clinical evaluation and management of cardiovascular health.

References

1. World Health Organization. Cardiovascular diseases (CVDs). [Internet]. 2020 [cited 2025 Oct 9]. Available from: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)
2. McArdle WD, Katch FI, Katch VL. Exercise physiology: Nutrition, energy, and human performance. 8th ed. Wolters Kluwer Health; 2015.
3. Plowman SA, Smith DL. Exercise physiology for health, fitness, and performance. 4th ed. Lippincott Williams & Wilkins; 2014.
4. Wilmore JH, Costill DL, Kenney WL. Physiology of sport and exercise. 4th ed. Human Kinetics; 2008.
5. Joyner MJ, Casey DP. Regulation of increased blood flow (hyperemia) to muscles during exercise: A hierarchy of competing physiological needs. Physiol Rev. 2015;95(2):549–601. https://doi.org/10.1152/physrev.00035.2013
6. Ministry of Health and Family Welfare (MoHFW). National Noncommunicable Disease Monitoring Survey (NNMS) 2017–18. Government of India; 2020.
7. Anjana RM, *et al*. Physical activity and inactivity patterns in India – Results from the ICMR-INDIAB study (Phase-1). Int J Behav Nutr Phys Act. 2014;11(1):26. https://doi.org/10.1186/1479-5868-11-26
8. Levine BD. VO_2max: What do we know, and what do we still need to know? J Physiol. 2008;586(1):25–34. https://doi.org/10.1113/jphysiol.2007.147629
9. Fagard RH. Athlete's heart. Heart. 2003;89(12):1455–61. https://doi.org/10.1136/heart.89.12.1455
10. Kemi OJ, Wisløff U. Cardiovascular adaptations to exercise training. Heart Fail Rev. 2010;15(1):71–9. https://doi.org/10.1007/s10741-008-9119-1
11. Mitchell JH, *et al*. Task Force 8: Classification of sports. J Am Coll Cardiol. 2005;45(8):1364–7. https://doi.org/10.1016/j.jacc.2005.02.015
12. Bassett DR, Howley ET. Limiting factors for VO_2max and endurance performance. Med Sci Sports Exerc. 2000;32(1):70–84. https://doi.org/10.1097/00005768-200001000-00012
13. Buchheit M, Laursen PB. High-intensity interval training: Solutions to the programming puzzle. Sports Med. 2013;43(5):313–38. https://doi.org/10.1007/s40279-013-0029-x
14. Zavorsky GS. Evidence and mechanisms of altered maximum heart rate with training. Sports Med. 2000;29(1):13–26. https://doi.org/10.2165/00007256-200029010-00002
15. Tanaka H, Seals DR. Masters athletes and human aging. J Appl Physiol. 2003;95(5):2152–62. https://doi.org/10.1152/japplphysiol.00320.2003