

Differential Adaptations in Resting Heart Rate Following Moderate-Intensity Aerobic and Sport-Specific Skill Training in University Athletes

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Abstract—The present study aimed to compare the differential adaptations in resting heart rate following moderate-intensity aerobic training and sport-specific skill training among university-level team sport athletes. Resting heart rate is an important physiological indicator of cardiovascular fitness, autonomic regulation, and training adaptation, and lower resting heart rates are generally associated with improved athletic performance and recovery. A randomized pre-test and post-test experimental design was employed for the study. Sixty-three male college athletes aged between 19 and 23 years, representing basketball, football, and handball, were selected using purposive random sampling. The subjects were randomly assigned into three groups: Moderate-Intensity Aerobic Training (MIAT; n = 21), Skill Training (SKT; n = 21), and Control Group (CG; n = 21). The experimental groups underwent their respective training interventions for 12 weeks, while the control group followed their regular activities without any specialized training programme. Resting heart rate was measured before and after the intervention period. The collected data were analyzed using the dependent t-test, Analysis of Covariance (ANCOVA), and Scheffé's post hoc test at a 0.05 level of significance. The findings revealed significant reductions in resting heart rate in both experimental groups. The dependent t-values of the MIAT (34.92) and SKT (13.29) groups were significantly higher than the table value (2.08). The ANCOVA results further demonstrated significant differences among the groups ($F = 130.37, p < 0.05$). The post hoc analysis indicated that both training methods were superior to the control group, with moderate-intensity aerobic training producing greater improvements in resting heart rate than skill training. The study concluded that moderate-intensity aerobic training is more effective than sport-specific skill training in eliciting favorable cardiovascular adaptations and reducing resting heart rate among university-level basketball, football, and handball athletes. The findings highlight the importance of incorporating aerobic conditioning programmes for enhancing cardiovascular efficiency, recovery capacity, and overall athletic performance in team sport athletes.

Keywords: Resting Heart Rate, Moderate-Intensity Aerobic Training, Skill Training, Team Sports, Cardiovascular Adaptation, University Athletes.

I. INTRODUCTION

Team sports such as basketball, football, and handball require a combination of physical fitness, physiological efficiency, technical proficiency, and tactical decision-making. Success in these sports depends on the athlete's ability to perform repeated high-intensity activities interspersed with periods of moderate and low-intensity movements. Therefore, physical and physiological characteristics play a crucial role in determining performance and competitive success. Basketball involves frequent sprinting, jumping, rapid changes of direction, and intermittent high-intensity actions, demanding both aerobic and

anaerobic capacities. Since these team sports involve intermittent bouts of exercise, athletes require efficient cardiovascular and respiratory functioning to maintain performance, delay fatigue, and facilitate rapid recovery during competition.

Physiological variables are essential indicators of an athlete's functional capacity and adaptation to training. Among these variables, cardiovascular and respiratory adaptations significantly influence sports performance. Regular physical training produces cardiovascular adaptations such as increased stroke volume, improved cardiac output, enhanced blood circulation, and a reduction in resting heart rate. These adaptations improve oxygen delivery to working muscles and enhance exercise efficiency. Respiratory adaptations include improved pulmonary ventilation, greater respiratory muscle efficiency, and enhanced oxygen exchange. Efficient pulmonary functioning enables athletes to sustain high exercise intensities, recover quickly between efforts, and maintain performance during prolonged competition.

Moderate-intensity aerobic training refers to continuous rhythmic physical activity performed at approximately 50–70% of maximum heart rate or 40–60% of oxygen uptake reserve. Activities such as jogging, cycling, and continuous running are commonly used forms of aerobic exercise. The fundamental principles of moderate-intensity aerobic training include overload, progression, specificity, and regularity. Training intensity is maintained at a level sufficient to stimulate cardiovascular adaptations while minimizing excessive fatigue. Physiological adaptations resulting from aerobic training include increased stroke volume, improved cardiac efficiency, enhanced capillary density, increased mitochondrial activity, and improved autonomic regulation of the heart. These adaptations often result in a lower resting heart rate and improved exercise economy.

Skill training refers to the systematic practice of sport-specific movements aimed at improving technical proficiency, coordination, and motor performance. It includes drills designed to enhance passing, shooting, dribbling, throwing, agility, reaction time, and tactical execution. Types of skill training include closed skills, open skills, repetitive drills, variable practice, and game-specific exercises. Repeated performance of these skills leads to neuromuscular adaptations such as improved motor unit recruitment, enhanced movement efficiency, faster reaction times, and better coordination. Skill training contributes significantly to sport-specific performance by improving movement economy and reducing unnecessary energy expenditure. Repeated skill execution also produces physiological adaptations, including improved cardiovascular efficiency, enhanced autonomic control, and better recovery responses, which may positively influence resting heart rate.

Resting heart rate (RHR) is defined as the number of heartbeats per minute when an individual is at complete physical and mental rest. It is usually measured after a period of quiet sitting or immediately upon waking in the morning. Resting heart rate is widely considered an important indicator of cardiovascular fitness and autonomic nervous system function. Well-trained athletes generally exhibit lower resting heart rates due to increased stroke volume, improved cardiac efficiency, and enhanced parasympathetic activity. A lower resting heart rate indicates that the heart can pump an adequate volume of blood with fewer contractions, reflecting superior cardiovascular adaptation and exercise efficiency. Resting heart rate is an important physiological marker of training adaptation and performance readiness in team sport athletes. In addition, reduced resting heart rate contributes to enhanced performance by improving exercise economy and delaying the onset of fatigue. Athletes with better cardiovascular efficiency can sustain repeated high-intensity actions, recover quickly during intermittent play, and maintain optimal performance throughout the duration of the game.

I.I. STATEMENT OF THE PROBLEM

"To compare the differential adaptations in resting heart rate following moderate-intensity aerobic and sport-specific skill training in university athletes."

I.II. OBJECTIVES OF THE STUDY

- To determine the effect of moderate-intensity aerobic training on resting heart rate.
- To determine the effect of skill training on resting heart rate.
- To compare the effectiveness of both training methods.

I.III. HYPOTHESES

There would be a significant difference in resting heart rate among athletes following moderate-intensity aerobic training and skill training.

II. METHODOLOGY

The present study employed a randomized pre-test and post-test experimental group design to investigate the comparative effects of moderate-intensity aerobic training and skill training on selected physical fitness and physiological characteristics among college athletes belonging to Basketball, Football, and Handball. For the purpose of this study, a total of 63 male college athletes aged between 19 and 23 years were selected from colleges and universities. The subjects were players of Basketball, Football, and Handball who had experience in intercollegiate level competitions. For each group 21 players were selected which consists of 7 athletes from basketball, 7 athletes from football, 7 athletes from handball. The subjects were selected using purposive random sampling method. The initial testing took place before the beginning of the training while the final testing was performed after 12 weeks of intervention with the moderate-intensity aerobic and skill training methods on selected physical and physiological variables.

The selected subjects were randomly assigned into different training groups, namely:

- ❖ Group-1 MIAT (Moderate-Intensity Aerobic Training)
- ❖ Group-2 SKT (Skill training)
- ❖ Group-3 CG (Control group)

The selection of variable for the present study was based on the requirements of team sports and the importance of resting heart rate efficiency in athletic performance. The variable was carefully chosen to evaluate the influence of moderate-intensity aerobic training and skill training on college athletes participating in Basketball, Football, and Handball. These two training methods such as moderate-intensity aerobic training and skill training served as the independent variables because they were the experimental treatments applied by the investigator to determine their influence on the selected dependent variables of the study. The dependent variables of the present study was resting heart rate and it is measured to determine the effects of moderate-intensity aerobic training and skill training on college athletes of Basketball, Football, and Handball. A statistical analysis was performed on the pre-test and post-test results were Paired 't' test, Analysis of Covariance (ANCOVA) and Schfee's Post Hoc to find out the significance among the mean differences. In all cases 0.05 level of significance was fixed to test the hypotheses.

III. RESULTS

The obtained resting heart rate data from the athletes of basketball, football and handball belongs to moderate-intensity aerobic training, skill training and control group (MIAT, SKT & CG) was analyzed by Paired 't' test, ANCOVA and Schfee's Post Hoc statistics. These results are put on view in tables-4.1 to 4.3.

IV. ANALYSIS OF RESTING HEART RATE

The found results by the applied dependent 't' test statistical procedure, so as to evaluate the efficiency of moderate-intensity aerobic training, skill training and control group (MIAT, SKT & CG) group's resting heart rate for basketball, football and handball athletes is in table-4.1.

Table 4.1 Descriptive Statistics of resting heart rate in Pre and Post Test of Moderate-Intensity Aerobic Training, Skill Training and Control Group of Basketball, Football and Handball Athletes

GROUP	TEST	MEAN	SD	DM	t-value
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MIAT	PRE	72.00	1.87	4.76	34.92*
	POST	67.23	1.70		
SKT	PRE	71.42	1.66	4.04	13.29*
	POST	67.38	1.85		
CG	PRE	72.00	1.87	0.47	4.26*
	POST	71.52	2.06		

Table value for df 20 is 2.08 (significant at 0.05)

The found results by the applied dependent ‘t’ test statistical procedure, confirm that the difference in resting heart rate mean values found between pre and post test of moderate-intensity aerobic training, skill training and control group (MIAT, SKT & CG) group’s vary noticeably, as the dependent ‘t’ values 34.92 (MIAT), 13.29 (SKT) and 4.26 (CG) are more than requisite to the table value for df 20 is 2.08.

In below specified table (table-4.2), the resultant ANCOVA statistic outcome on resting heart rate of moderate-intensity aerobic training, skill training and control group (MIAT, SKT & CG) of basketball, football and handball athletes are given.

Table 4.2 ANCOVA results obtained on resting heart rate of Basketball, Football and Handball Athletes belongs to Moderate-Intensity Aerobic Training, Skill Training and Control Groups

MEAN	MIAT	SKT	CG	SOV	SS	df	MS	F-ratio
Pre test	72.00	71.42	72.00	B	4.57	2	2.28	0.70
				W	195.14	60	3.25	
Post test	67.23	67.38	71.52	B	248.85	2	124.42	35.21*
				W	212.00	60	3.53	
Adj post test	67.23	67.38	71.52	B	222.82	2	111.41	130.37*
				W	50.41	59	0.85	

(Table value for df 2 & 60 are 3.15)*Significant (0.05 level)

The ANCOVA results demonstrate that the resting heart rate of pre, post and adj post tests mean values of moderate-intensity aerobic training (MIAT = 72.00, 67.23, 67.23), skill training (SKT = 71.42, 67.38, 67.38) as well as control groups (CG= 72.00, 71.52, 71.52) of basketball, football and handball athletes are different from each other. Because the applied ANCOVA statistics, ‘F’ value (0.70, 35.21, 130.37) of moderate-intensity aerobic training, skill training and control group is more than 3.15 (table value) for 2 and 60 degrees of freedom (df).

In below presented table (table-4.3), the applied post hoc test (Scheffe’s) results on resting heart rate of moderate-intensity aerobic training, skill training and control group (MIAT, SKT & CG) of basketball, football and handball athletes are given

Table – 4.3 Scheffe’s Test Results Obtained on resting heart rate of Basketball, Football and Handball Athletes belongs to Moderate-Intensity Aerobic Training, Skill Training and Control Groups

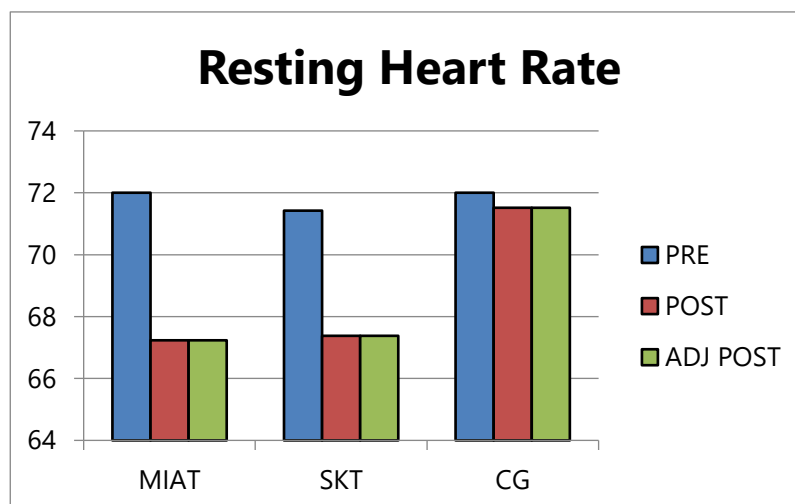
MIAT	SKT	CG	MD	CI
67.23	67.38		0.15*	0.71
	67.38	71.52	4.14*	0.71
67.23		71.52	4.29*	0.71

*Significant at (0.05)

The Scheffe’s results makes apparent that due to Moderate-Intensity Aerobic training (MIAT =67.23), Skill Training (SKT =67.38) and Control Groups (CG = 71.52) of the Basketball, Football and Handball athlete’s resting heart rate was improved very much, as these mean differences with these groups (0.15, 4.14, 4.29) are better to 0.03 (CI value). Although, Moderate-Intensity Aerobic training group and Skill Training group are much better in performance when compared to control group. However, Skill Training group is much better than Moderate-Intensity Aerobic training group.

The below displayed graph (Figure-I), showing the Resting Heart Rate of moderate-intensity aerobic training, skill training and control group (MIAT, SKT & CG) of basketball, football and handball athletes are given

Figure – 1 Graph Showing the Resting Heart Rate of Basketball, Football and Handball Athletes belongs to Moderate-Intensity Aerobic Training, Skill Training and Control Groups



V. DISCUSSION

The findings of the present study revealed that moderate-intensity aerobic training significantly reduced resting heart rate among university-level basketball, football, and handball athletes. Resting heart rate is considered a reliable indicator of cardiovascular efficiency and autonomic regulation, and reductions in resting heart rate following aerobic training reflect positive physiological adaptations. One of the primary mechanisms responsible for the reduction in resting heart rate is the improvement in cardiac efficiency and stroke volume. Regular aerobic exercise increases the size and functional capacity of the left ventricle, enabling the heart to pump a greater volume of blood with each contraction. Consequently, fewer heartbeats are required to maintain adequate circulation at rest. According to B. A. Franklin et al. (2022), aerobic training enhances parasympathetic activity and increases stroke volume, leading to significant reductions in resting heart rate among trained

individuals. Moderate-intensity aerobic training also improves autonomic nervous system regulation. Chronic aerobic exercise increases vagal tone and reduces sympathetic activity, resulting in greater cardiac efficiency and lower resting heart rate. J. A. M. da Silva et al. (2021) reported that endurance-based exercise programs significantly improve autonomic balance, producing reductions in resting heart rate and improvements in cardiovascular health. Another important adaptation is improved oxygen transport and utilization. Aerobic exercise increases capillary density, mitochondrial content, and oxidative enzyme activity, thereby enhancing the ability of skeletal muscles to extract and utilize oxygen. Because oxygen delivery becomes more efficient, the cardiovascular system can maintain metabolic demands with less cardiac effort. M. Montero et al. (2023) demonstrated that aerobic conditioning improves cardiovascular efficiency and decreases resting heart rate through enhanced oxygen utilization and peripheral adaptations. Moderate-intensity aerobic training also enhances recovery capacity. Athletes with lower resting heart rates generally exhibit faster post-exercise recovery and improved resilience to repeated bouts of high-intensity activity. D. Buchheit and colleagues (2022) observed that lower resting heart rate is associated with superior recovery profiles and better readiness for repeated performance in team sport athletes. The reduction in resting heart rate observed in the present study may therefore be attributed to increased stroke volume, improved autonomic regulation, enhanced oxygen transport, and superior cardiovascular efficiency produced by moderate-intensity aerobic training.

The findings also indicated that sport-specific skill training significantly reduced resting heart rate, although the magnitude of improvement was smaller than that observed following moderate-intensity aerobic training. Skill training primarily improves neuromuscular efficiency and movement economy. Repeated practice of sport-specific activities enables athletes to execute movements with less energy expenditure and lower physiological stress. According to N. A. Bishop et al. (2021), improvements in movement efficiency reduce cardiovascular strain during training and may contribute to modest reductions in resting heart rate. Basketball, football, and handball involve intermittent high-intensity actions such as sprinting, jumping, throwing, and rapid directional changes. Repeated exposure to these activities imposes considerable demands on both the cardiovascular and neuromuscular systems. Over time, these demands produce physiological adaptations, including improved autonomic control and enhanced cardiovascular responsiveness. Sport-specific skill training also exposes athletes to repeated short-duration exercise bouts interspersed with recovery periods. Such intermittent activity patterns have been shown to improve cardiovascular function and cardiac autonomic modulation. M. Iaia et al. (2022) reported that repeated intermittent exercise enhances cardiovascular adaptations and contributes to reductions in resting heart rate in team sport athletes. Furthermore, sport-specific training improves exercise economy by reducing unnecessary muscular activity and increasing coordination between muscle groups. T. Stølen et al. (2023) noted that improved movement efficiency and neuromuscular coordination lower cardiovascular stress and contribute to favorable adaptations in resting heart rate. Although skill training may not provide the continuous cardiovascular stimulus associated with aerobic exercise, repeated sport-specific movements can still induce meaningful adaptations in cardiac function and autonomic regulation.

The present study demonstrated that both moderate-intensity aerobic training and sport-specific skill training significantly improved resting heart rate; however, moderate-intensity aerobic training produced greater reductions. The superior effectiveness of aerobic training may be attributed to the continuous and sustained cardiovascular demands imposed by aerobic exercise. Prolonged exercise at moderate intensity stimulates central cardiovascular adaptations, including increased stroke volume, enhanced cardiac output, improved autonomic regulation, and greater oxygen transport efficiency. According to B. A. Franklin et al. (2022), endurance-based exercise programs consistently produce larger reductions in resting heart rate than intermittent sport-specific activities because they elicit greater improvements in parasympathetic tone and cardiac efficiency. Similarly, P. B. Sparling et al. (2024) reported that aerobic conditioning remains one of the most effective interventions for improving cardiovascular efficiency and reducing resting heart rate in athletes and physically active individuals.

The findings of the present investigation are therefore consistent with previous studies demonstrating that moderate-intensity aerobic exercise produces superior cardiovascular adaptations compared with sport-specific training alone. From a practical perspective, lower resting heart rate is associated with improved recovery, reduced physiological strain, enhanced endurance capacity, and greater readiness for competition. According to D. Buchheit et al. (2022), resting heart rate serves as an important

marker of adaptation and readiness in athletes participating in intermittent team sports. These mechanisms collectively explain the reductions in resting heart rate following both training interventions.

VI. CONCLUSION

The present study investigated the comparative effects of moderate-intensity aerobic training and sport-specific skill training on resting heart rate among university-level basketball, football, and handball athletes. The findings revealed that both training interventions produced significant improvements in resting heart rate. However, moderate-intensity aerobic training demonstrated greater effectiveness in reducing resting heart rate compared with sport-specific skill training. The hypothesis stating that there would be a significant differences among the training interventions was therefore rejected, while the hypothesis was accepted. The findings indicate that moderate-intensity aerobic training is superior in eliciting favorable adaptations in resting heart rate among university-level team sport athletes. The study further suggests that regular monitoring of resting heart rate can assist coaches in evaluating training responses, detecting fatigue, and designing individualized conditioning programs. Future investigations may examine the long-term effects of combined training interventions and include additional physiological variables such as heart rate variability, maximal oxygen uptake, and recovery indices to provide a more comprehensive understanding of training adaptations in team sport athletes.

REFERENCE

1. Rochat, I., Côté, A., & Boulet, L. P. (2022). Determinants of lung function changes in athletic swimmers. A review. *Acta Paediatrica*, 111(2), 259-264.
2. Karaduman, E., Bostancı, Ö., & Bayram, L. (2022). Respiratory muscle strength and pulmonary functions in athletes: differences by BMI classifications.
3. Feng, X., Zhao, L., Chen, Y., Wang, Z., Lu, H., & Wang, C. (2023). Optimal type and dose of hypoxic training for improving maximal aerobic capacity in athletes: a systematic review and Bayesian model-based network meta-analysis. *Frontiers in Physiology*, 14, 1223037.
4. Huang, Z., Yang, S., Li, C., Xie, X., & Wang, Y. (2023). The effects of intermittent hypoxic training on the aerobic capacity of exercisers: a systemic review and meta-analysis. *BMC Sports Science, Medicine and Rehabilitation*, 15(1), 174.
5. Akinci, B., Cilbir, C. E., Kocyigit, A., & Aslan, G. K. (2024). Respiratory muscle training in para-athletes: A systematic review on the training protocols and effects on reported outcomes. *Journal of Sport Rehabilitation*, 33(6), 387-395.
6. Xavier, D. M., de Miranda, J. P., Figueiredo, P. H. S., & Lima, V. P. (2025). The effectiveness of respiratory muscular training in athletes: A systematic review and meta-analysis. *Journal of Bodywork and Movement Therapies*, 42, 777-792.
7. Wagh, P., Kumar, K. V., Buge, K. H., & Kumar, S. Study of pulmonary function tests and muscle strength in sportsmen of tribal region of Gujarat. *International Journal of Health Sciences*, (II), 2172-2182.
8. Yogeve, A., Arnold, J. I., Nelson, H., Rosenblat, M. A., Clarke, D. C., Guenette, J. A., & Koehle, M. S. (2024). The effects of endurance training on muscle oxygen desaturation during incremental exercise tests: a systematic review and meta-analysis. *Frontiers in sports and active living*, 6, 1406987.
9. Carvajal-Tello, N., Ortega, J. G., Caballero-Lozada, A. F., Devia-Quiñonez, M. J., González-Calzada, I., Rojas-Hernández, D., & Segura-Ordoñez, A. (2024). Effects of inspiratory muscle training on lung function parameter in swimmers: a systematic review and meta-analysis. *Frontiers in Sports and Active Living*, 6, 1429902.
10. Thomsen, R. S., Rasmussen, R. S., Madsen, A. C., Iepsen, U. W., Christensen, R. H., & Berg, R. M. (2025). Standardised lung function metrics in healthy athletes. *Scandinavian Journal of Clinical and Laboratory Investigation*, 85(1), 20-27.



11. Tomčić, J., Šarabon, N., & Marković, G. (2021). Factorial structure of trunk motor qualities and their association with explosive movement performance in young footballers. *Sports*, 9(5), 67.
12. Song, T., & Deng, Y. (2023). Physiological and biochemical adaptations to a sport-specific sprint interval training in male basketball athletes. *Journal of Sports Science & Medicine*, 22(4), 605.
13. Clemente, F. M., Afonso, J., & Sarmiento, H. (2021). Small-sided games: An umbrella review of systematic reviews and meta-analyses. *PloS one*, 16(2), e0247067.
14. McPhail, J., Cross, M. R., Spörri, J., & Linnamo, V. (2024). Physiological Characteristics of Freestyle Snowboard and Freeski Athletes. *International Journal of Sports Physiology and Performance*, 20(2), 301-308.
15. Castagna, C., Krustup, P., Nassis, G. P., Randers, M. B., Brito, J., & Mohr, M. (2025). Physical and Physiological Demands of Football. In *Strength and Conditioning for Football* (pp. 3-20). Routledge.
16. Stankovic, M., Djordjevic, D., Trajkovic, N., & Milanovic, Z. (2023). Effects of high-intensity interval training (HIIT) on physical performance in female team sports: a systematic review. *Sports medicine-open*, 9(1), 78.
17. Buchheit, M., Shushan, T., Barrett, S., Scott, T. J., Altmann, S., Rabbani, A., ... & McLaren, S. J. (2025). Maximizing the submaximal: 20 years of monitoring cardiovascular adaptation through submaximal HR response in team sports. *Sport Performance & Science Reports*, 266, 1-36.
18. Bascuas, P. J., Gutiérrez, H., Piedrafita, E., Bataller-Cervero, A. V., & Berzosa, C. (2024). Study of Physiological Adaptations in Vertical Kilometer Runners: Focus on Cardiorespiratory and Local Muscle Demands. *Journal of Functional Morphology and Kinesiology*, 9(4), 230.
19. Longhini, L. S., Zena, L. A., Polymeropoulos, E. T., Rocha, A. C., da Silva Leandro, G., Prado, C. P., ... & Gargaglioni, L. H. (2021). Thermal acclimation to the highest natural ambient temperature compromises physiological performance in tadpoles of a stream-breeding savanna tree frog. *Frontiers in Physiology*, 12, 726440.