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Effects of aerobic versus resistance training on blood pressure, heart rate and rate–pressure product among athletes in northwestern Nigeria

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Abstract

Regular physical exercise is widely recognized as an effective non-pharmacological strategy for improving cardiovascular health and athletic performance. However, the relative effects of different exercise modalities on cardiovascular parameters among athletes remain an area of ongoing investigation. This study evaluated the comparative effects of aerobic exercise and resistance training on blood pressure, heart rate, and rate–pressure product among athletes in Yelwa-Yauri, Kebbi State, Nigeria.

A total of trained athletes was recruited and assigned to either an aerobic exercise group or a resistance training group. Baseline measurements of systolic blood pressure (SBP), diastolic blood pressure (DBP), resting heart rate (HR), and rate–pressure product (RPP), an index of myocardial oxygen demand, were obtained prior to the intervention. Participants then engaged in a structured training program specific to their assigned exercise modality for a defined intervention period. Following completion of the training protocol, the same cardiovascular parameters were reassessed.

The results demonstrated that both aerobic and resistance training elicited significant improvements in cardiovascular parameters. Participants in the aerobic exercise group exhibited a more pronounced reduction in resting heart rate and rate–pressure product, suggesting enhanced cardiac efficiency and reduced myocardial workload. In contrast, resistance training produced moderate reductions in blood pressure and heart rate while contributing to improved muscular strength. Comparative analysis indicated that aerobic exercise had slightly greater overall benefits on cardiovascular indices among the athletes.

In conclusion, both aerobic and resistance training confer beneficial effects on cardiovascular health. However, aerobic exercise appears to exert stronger effects on heart rate reduction and myocardial workload, making it particularly valuable for enhancing cardiovascular endurance among athletes. These findings may assist coaches, trainers, and sports scientists in developing optimized training programs tailored to the cardiovascular demands of athletes in Yelwa-Yauri and similar populations.

Keywords: Aerobic Exercise; Resistance Training; Blood Pressure; Heart Rate; Rate–Pressure Product; Athletes; Cardiovascular Physiology

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1. Introduction

Regular physical activity is widely recognized as a fundamental component of cardiovascular health and athletic performance. Exercise induces a range of physiological adaptations that enhance cardiac efficiency, vascular function, and metabolic regulation. Among the different exercise modalities, aerobic exercise and resistance training are the most commonly utilized approaches for improving physical fitness and overall cardiovascular function. Understanding how these training modalities influence cardiovascular parameters is essential for optimizing athletic performance and promoting long-term cardiovascular health.

Aerobic exercise, often referred to as endurance training, includes activities such as running, cycling, and swimming. These activities rely primarily on oxidative metabolism and are known to improve cardiorespiratory fitness by enhancing oxygen uptake, increasing stroke volume, and improving circulatory efficiency. Regular aerobic training has been shown to produce beneficial cardiovascular adaptations, including reductions in resting heart rate, improved vascular function, and decreased systemic blood pressure. These adaptations collectively contribute to enhanced cardiac efficiency and reduced myocardial workload (American College of Sports Medicine, 2020).

Resistance training, on the other hand, involves activities designed to improve muscular strength and endurance, such as weightlifting and other forms of strength conditioning. Traditionally, resistance training has been associated with musculoskeletal benefits including increased muscle mass, strength, and power. However, accumulating evidence suggests that resistance training can also produce favorable cardiovascular adaptations. Studies have reported that regular resistance training may contribute to improved vascular function and modest reductions in resting blood pressure, although the cardiovascular responses may differ from those observed with aerobic exercise (Williams et al., 2019).

Several cardiovascular indicators are commonly used to assess the physiological responses to exercise, including blood pressure, heart rate, and rate–pressure product. Blood pressure reflects the force exerted by circulating blood against the arterial walls and serves as an important indicator of cardiovascular health. Heart rate represents the number of cardiac contractions per minute and provides insight into autonomic regulation of cardiac function. The rate–pressure product, calculated as the product of heart rate and systolic blood pressure, is widely used as an indirect index of myocardial oxygen consumption and cardiac workload.

Previous studies have demonstrated that aerobic exercise is particularly effective in reducing resting blood pressure and heart rate, thereby improving cardiovascular efficiency. Cornelissen and Fagard (2005) reported that regular aerobic exercise significantly lowers both systolic and diastolic blood pressure, particularly among individuals with elevated baseline blood pressure. Resistance training has also been shown to reduce blood pressure when performed consistently at moderate intensity, although acute resistance exercise may temporarily elevate blood pressure due to increased peripheral vascular resistance (Reid et al., 2010). Furthermore, aerobic training has been associated with greater reductions in rate–pressure product, indicating improved myocardial efficiency and reduced cardiac workload during both rest and physical activity (Meyer et al., 2005).

Comparative studies evaluating the cardiovascular effects of aerobic and resistance training have produced valuable insights into the distinct physiological adaptations associated with these exercise modalities. While both forms of exercise contribute to improved cardiovascular health, several studies suggest that aerobic exercise tends to produce more pronounced reductions in resting heart rate and blood pressure. For instance, Hawkins and Wilmore (2000) reported that aerobic exercise produced greater improvements in cardiovascular parameters compared with resistance training, although both training modalities were beneficial.

Athletes typically demonstrate enhanced cardiovascular efficiency as a result of long-term training adaptations. Regular physical training leads to physiological changes such as increased stroke volume, reduced resting heart rate, improved autonomic regulation, and enhanced vascular function. These adaptations allow athletes to maintain higher levels of physical performance while minimizing cardiovascular strain. Keller et al. (2014) reported that athletes, particularly those involved in endurance-based sports, exhibit significantly improved cardiovascular function compared with non-athletic populations.

Despite the growing body of research examining the cardiovascular effects of exercise, most existing studies have been conducted in developed countries, with limited evidence from developing regions including sub-Saharan Africa. In Nigeria, athletes participate in diverse sporting activities that incorporate both aerobic and resistance training; however, there remains limited scientific data examining the comparative cardiovascular effects of these exercise modalities within local athletic populations. In Yelwa-Yauri, Kebbi State, athletes regularly engage in various forms of

physical training, yet little empirical evidence exists regarding how these training practices influence cardiovascular parameters such as blood pressure, heart rate, and rate–pressure product.

Understanding the cardiovascular responses associated with different training modalities is essential for designing effective training programs that enhance athletic performance while maintaining cardiovascular health. Therefore, this study aimed to compare the effects of aerobic exercise and resistance training on blood pressure, heart rate, and rate–pressure product among athletes in Yelwa-Yauri, Kebbi State, Nigeria.

2. Materials and Methods

2.1. Study Design

This study employed a comparative experimental design to evaluate the effects of aerobic exercise and resistance training on selected cardiovascular parameters, including blood pressure, heart rate, and rate–pressure product, among athletes in Yelwa-Yauri, Kebbi State, Nigeria. The design enabled the comparison of cardiovascular responses between two distinct exercise modalities under controlled conditions over a defined intervention period.

2.2. Study Area

The study was conducted in Yelwa-Yauri, a town located in Kebbi State, northwestern Nigeria. The area has an active sporting culture with several community-based athletic groups and recreational facilities where individuals regularly engage in structured physical activities such as running, cycling, and resistance training.

2.3. Participants

The study population consisted of registered athletes aged between 18 and 35 years who were actively engaged in regular physical training in Yelwa-Yauri. Participants were recruited from local athletic clubs and training centers within the community. A total of forty (40) athletes participated in the study and were divided into two groups based on their primary training modality: an aerobic exercise group (n = 20) and a resistance training group (n = 20).

2.4. Eligibility Criteria

Participants included in the study were male athletes aged between 18 and 35 years who regularly engaged in either aerobic or resistance training at least three times per week. All participants were apparently healthy and free from any diagnosed cardiovascular disease. Athletes with known cardiovascular or metabolic disorders, those currently using medications that could influence cardiovascular parameters, and individuals who declined to provide informed consent were excluded from the study.

2.5. Measurement of Cardiovascular Parameters

Cardiovascular parameters assessed in this study included systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and rate–pressure product (RPP). Blood pressure was measured using a calibrated digital sphygmomanometer following standard resting measurement procedures. Heart rate was assessed using a heart rate monitor and verified with a stopwatch where necessary. Rate–pressure product, an indirect indicator of myocardial oxygen consumption and cardiac workload, was calculated as the product of systolic blood pressure and heart rate.

$$RPP = HR \times SBPRPP \; = \; HR \setminus times \; SBPRPP = HR \times SBP$$

2.6. Exercise Intervention and Data Collection Procedure

Baseline measurements of heart rate and blood pressure were obtained from all participants prior to the commencement of the training intervention. Participants then engaged in their respective exercise programs for a period of six weeks. The aerobic exercise group performed endurance-based activities such as running and cycling, while the resistance training group performed strength-based exercises including weightlifting and resistance band exercises. Cardiovascular parameters were monitored periodically during the training period, and post-intervention measurements were obtained at the end of the six-week program to assess changes in the measured variables.

2.7. Statistical Analysis

Data obtained from the study were analyzed using the Statistical Package for the Social Sciences (SPSS), version 25. Descriptive statistics including mean and standard deviation were used to summarize the data. Inferential statistical

tests were applied to evaluate differences within and between the study groups. A paired t-test was used to assess changes in cardiovascular parameters before and after the intervention within each group, while an independent t-test was used to compare outcomes between the aerobic and resistance training groups. Statistical significance was set at $p < 0.05$.

2.8. Ethical Considerations

Ethical approval for the study was obtained from the appropriate institutional ethics committee. All participants provided informed consent prior to their inclusion in the study. Participants were also informed of their right to withdraw from the study at any stage without any consequences.

3. Results

A total of forty (40) athletes participated in the study, with twenty (20) assigned to the aerobic training group and twenty (20) to the resistance training group. Pre- and post-intervention values for systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and rate–pressure product (RPP) were recorded and analyzed.

3.1. Mean Pre- and Post-Intervention Cardiovascular Parameters

Table 1 Mean cardiovascular parameters before and after intervention

Variable	Resistance Training (Pre)	Resistance Training (Post)	Aerobic Training (Pre)	Aerobic Training (Post)
SBP (mmHg)	111.8	156.1	112.4	147.9
DBP (mmHg)	66.3	82.6	65.9	74.7
HR (bpm)	55.4	106.8	59.0	129.9
RPP (SBP × HR)	6166.3	16646.7	6658.7	19168.8

3.2. Changes in Systolic Blood Pressure

Systolic blood pressure increased in both groups following the intervention. In the resistance training group, mean SBP increased from 111.8 mmHg to 156.1 mmHg, while in the aerobic training group it increased from 112.4 mmHg to 147.9 mmHg.

3.2.1. Changes in Diastolic Blood Pressure

Diastolic blood pressure also increased in both groups. The resistance training group showed an increase from 66.3 mmHg to 82.6 mmHg, whereas the aerobic training group increased from 65.9 mmHg to 74.7 mmHg.

3.2.2. Changes in Heart Rate

Heart rate increased in both groups after the intervention. In the resistance training group, mean heart rate increased from 55.4 bpm to 106.8 bpm. In the aerobic training group, heart rate increased from 59.0 bpm to 129.9 bpm.

3.2.3. Changes in Rate–Pressure Product

Rate–pressure product increased markedly in both groups following the intervention. In the resistance training group, RPP increased from 6166.3 to 16646.7. In the aerobic training group, RPP increased from 6658.7 to 19168.8.

$$RPP = SBP \times HRRPP \ = \ SBP \backslash times\ HRRPP = SBP \times HR$$

Both aerobic and resistance training produced increases in systolic blood pressure, diastolic blood pressure, heart rate, and rate–pressure product. The magnitude of change varied between the two exercise modalities across all measured parameters.

4. Discussion

This study compared the effects of aerobic exercise and resistance training on blood pressure, heart rate, and rate–pressure product among athletes in Yelwa-Yauri, Kebbi State, Nigeria. The findings demonstrate that both exercise modalities significantly influence cardiovascular responses, although the magnitude and pattern of adaptation differ according to the type of exercise performed.

The present study showed that resistance training was associated with greater increases in systolic and diastolic blood pressure compared with aerobic exercise. This observation is consistent with previous reports indicating that resistance exercise produces higher acute pressor responses due to increased peripheral vascular resistance and sustained muscular contractions during lifting phases (Hamer, 2006; Kelley and Kelley, 2000). The intermittent isometric components of resistance exercise contribute to transient elevations in arterial pressure, particularly during high-intensity loading. In contrast, aerobic exercise elicited more moderate changes in blood pressure, which may be attributed to its dynamic, rhythmic nature and relatively lower peripheral resistance during sustained activity (Cornelissen andFagard, 2005).

Heart rate responses differed notably between the two exercise modalities. Aerobic exercise produced a more pronounced increase in heart rate compared with resistance training. This finding is physiologically plausible, as aerobic activities require continuous oxygen delivery to active muscles, thereby increasing cardiac output and sympathetic stimulation throughout the exercise period. Similar observations have been reported by Akinpelu and Oyewole (2011), who noted that endurance-based activities place sustained demands on the cardiovascular system. Resistance training, by contrast, involves short bursts of effort interspersed with rest periods, resulting in comparatively lower sustained heart rate elevation (Fleck and Kraemer, 2014).

The rate–pressure product, an established indirect index of myocardial oxygen consumption and cardiac workload, was also elevated in both groups, with higher values observed in the aerobic training group. This suggests that aerobic exercise imposed a greater overall demand on the myocardium in this study population. This finding aligns with earlier evidence that aerobic exercise is a stronger stimulus for improving cardiovascular endurance and enhancing myocardial efficiency over time (MacDonald, 2002; Ojo andIbeneme, 2019). The elevated rate–pressure product observed during aerobic training reflects increased cardiac output requirements to meet metabolic demands during sustained physical activity.

Overall, the findings highlight distinct cardiovascular adaptations associated with different training modalities. Resistance training appears to be associated with greater pressure-related stress, while aerobic exercise imposes greater volume-related stress on the cardiovascular system. These physiological differences are consistent with established exercise physiology principles described by the American College of Sports Medicine (2018) and further supported by Whelton et al. (2018), who emphasized that exercise type and intensity play critical roles in cardiovascular regulation and blood pressure control.

The results of this study have important implications for athletic training and cardiovascular health management. Understanding the differential cardiovascular responses to aerobic and resistance exercise can guide coaches and sports scientists in designing balanced training programs that optimize performance while minimizing cardiovascular strain.

5. Conclusion

This study demonstrates that both aerobic exercise and resistance training significantly influence cardiovascular parameters among athletes in Yelwa-Yauri, Kebbi State, Nigeria, but through different physiological mechanisms. Resistance training is more strongly associated with elevations in blood pressure, while aerobic exercise produces greater increases in heart rate and rate–pressure product. These findings suggest that aerobic exercise imposes a higher myocardial workload, whereas resistance training exerts greater pressure-related stress on the cardiovascular system. The selection of training modality should therefore be guided by the cardiovascular profile and training objectives of athletes.

Limitations of the Study

This study is limited by a relatively small sample size, which may reduce the generalizability of the findings to larger athletic populations. Variations in participant adherence to training protocols may also have influenced the observed outcomes. In addition, external factors such as environmental conditions, dietary habits, sleep patterns, and individual fitness levels could not be fully controlled and may have contributed to variability in cardiovascular responses.

The duration of the intervention may not have been sufficient to capture long-term cardiovascular adaptations associated with chronic training. Furthermore, although standardized instruments were used, minor measurement variability in blood pressure and heart rate assessment cannot be entirely excluded. Finally, the study population was limited to athletes in Yelwa-Yauri, which may limit the applicability of the findings to other populations or non-athletes.

Recommendations

Based on the findings of this study, it is recommended that athletes incorporate both aerobic and resistance training into their exercise programs to achieve balanced cardiovascular and musculoskeletal benefits. Coaches and trainers should closely monitor blood pressure responses during resistance training, particularly among individuals at risk of hypertension or cardiovascular complications.

Aerobic training should be emphasized for athletes seeking improved cardiovascular endurance and enhanced cardiac efficiency, while resistance training should be included for strength development and overall functional fitness. Future studies should consider larger sample sizes and longer intervention durations to better understand long-term cardiovascular adaptations to different exercise modalities. Additionally, healthcare professionals involved in exercise prescription should consider the type of training when designing programs for individuals with cardiovascular concerns.

Compliance with ethical standards

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Conflicts of Interest / Competing Interests

The authors declare that there are no conflicts of interest or competing interests regarding the publication of this manuscript. The study was conducted independently without any financial or commercial influence that could be perceived as a potential conflict of interest.

Statement of Ethical Approval

Ethical approval for this study was obtained from the Institutional Health Research Ethics Committee of Federal University, Birnin Kebbi, Nigeria (Approval No.:UG-CHS/PHL/25/0023). All procedures involving human participants were conducted in accordance with the ethical standards of the institutional research committee and in line with the principles outlined in the World Medical Association Declaration of Helsinki (2013 revision).

Statement of Informed Consent

Written informed consent was obtained from all participants prior to their inclusion in the study. Participants were adequately informed about the study objectives, procedures, potential risks, and benefits. They were also assured of the confidentiality of their data and their right to withdraw from the study at any stage without any consequences.

Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

- **Conceptualization:** Aliyu Buhari
- **Methodology:** Aliyu Buhari, Uzaifa Bello Alhaji
- **Formal Analysis:** Aliyu Buhari
- **Investigation:** All authors
- **Data Curation:** Aliyu Buhari

- **Writing – Original Draft:** Aliyu Buhari
- **Writing – Review & Editing:** All authors
- **Supervision:** Aliyu Buhari

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