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Comparative Effects of Bicycle Ergometer and Treadmill Exercise on Cardiovascular Parameters among Nigerian Men in Abuja

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ABSTRACT

The choice of aerobic exercise modality has been a topic of scientific interest, with ongoing debate regarding whether specific exercise modes produce distinct physiological benefits measurable through cardiopulmonary and hemodynamic indices. This study investigated the comparative effects of bicycle ergometer (BE) and treadmill (TM) exercise on cardiovascular parameters among Nigerian adult males residing in Abuja. Forty healthy participants (N = 40), aged 20–50 years, voluntarily enrolled and were randomly assigned into two exercise intervention groups (TM, n = 20; BE, n = 20). Key cardiovascular variables—including pulse rate (PR), systolic blood pressure (SP), diastolic blood pressure (DP), pulse pressure (PP), and mean arterial pressure (MAP), were assessed before and immediately after exercise sessions using standardized protocols. Post-exercise means values following TM showed lower cardiovascular indices compared with BE: SP (134.20 ± 8.28 mmHg vs. 141.30 ± 12.34 mmHg), DP (86.95 ± 13.43 mmHg vs. 87.55 ± 16.31 mmHg), PP (45.90 ± 18.62 mmHg vs. 53.65 ± 15.39 mmHg), and MAP (102.25 ± 9.06 mmHg vs. 105.03 ± 13.40 mmHg). Although these reductions were not statistically significant ($p > 0.05$), the observed trend indicates that TM exercise elicited a comparatively lower hemodynamic load than BE exercise. This suggests that treadmill exercise may offer greater cardiovascular regulatory benefits, potentially lowering blood pressure values more effectively than cycling-based exercise. In conclusion, treadmill exercise demonstrates a more favorable cardiovascular response and may serve as a preferred modality in exercise prescriptions aimed at cardiovascular health promotion and prevention of blood pressure-associated morbidity. Further studies with larger, gender-balanced cohorts and longitudinal follow-up are recommended.

Keywords: Cardiovascular parameters, Exercise, Treadmill, Ergometer

Introduction

The cardiovascular system plays a crucial role in maintaining the transport of oxygen, nutrients, and other vital substances throughout the body. Regular physical activity has been widely recognized as a key factor in promoting cardiovascular health, and exercise modalities such as treadmill running and bicycle ergometry are commonly used for assessing and improving cardiovascular fitness (American Heart

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Association, 2022). Both exercise modes elicit a cardiopulmonary response, but they differ in their biomechanical, metabolic, and physiological demands (Estevão-Scudese *et al*., 2025; Marshall *et al*., 2025). Understanding the comparative effects of these exercise modalities on cardiovascular parameters, such as heart rate, blood pressure, and oxygen consumption, is critical for optimizing exercise prescriptions and enhancing cardiovascular health outcomes (Ngabea *et al.,* 2025).

Research on the effects of different exercise modalities on cardiovascular health has shown varying outcomes. Studies have demonstrated that both treadmill and bicycle ergometer exercises can improve aerobic capacity, heart rate variability, and blood pressure control (Rinaldi *et al*., 2022; Corso *et al*., 2023). Treadmill exercise, which involves weight-bearing activity, has been associated with higher energy expenditure and greater cardiovascular strain compared to the non-weight-bearing bicycle ergometer (Mahmood *et al*., 2022). Conversely, the bicycle ergometer is often favored for its lower impact on joints and controlled incremental workload, making it suitable for individuals with musculoskeletal limitations (Guo *et al*., 2023). Albeit, some studies have addressed the general cardiovascular benefits of aerobic exercise on pulse rate, systolic and diastolic blood pressure, pulse pressure, and mean arterial pressure, as they show how exercise contributes to arteriole dilation, and hence decreases both the systolic (SP) and diastolic pressure (DP) (Guo *et al*., 2023). Since sustained increase in blood pressure is a major contributor of cardiovascular disorders and mortality globally; hence any attempt to get rid of this sustain increase in BP via exercise routine has promising effect on longevity and overall health (Pereira *et al*., 2023). The regulation of mean arterial pressure (MAP) also as enormous benefit in ensuring organs have sufficient and constant aeration which is needed for optimum body function (Pereira *et al*., 2023; Thompson & Lee, 2024). Despite all these enormous benefits of exercise on some major cardiovascular indices there are still paucity of information on personalize exercise plans and the generalize exercise may have little or no profound benefit on individuals as they may have different mechanism on cardiovascular parameters, and most of these studies are non-gender specific, considering there are differences in physiological range of MAP, PP, SP and DP in male and female. This study aims to compare the effects of bicycle ergometer and treadmill exercises on key cardiovascular parameters such as heart rate and blood pressure in a healthy adult male population.

2.0 Materials and Method

Study Design and Participants

This experimental study was conducted among the members of Baze University community in September 2024. The study employed a randomized crossover trial as carried out by Ochayi *et al*. (2025). This design compare the effects of bicycle ergometer and treadmill exercises on cardiovascular parameters. A total of 40 healthy male participants who indicated to be involved with mild to moderate exercise frequently using convenience sampling method; they are between the ages of 20 and 50. The participants with cardiovascular, pulmonary, or musculoskeletal disorders, as well as those with current or past cardiovascular disease, respiratory conditions, or inability to complete maximal exercise testing, were excluded from the study, and participants were instructed to avoid alcohol, caffeine, and vigorous physical activity for at least 24 hours before each testing session to standardize baseline conditions (Wilkins *et al*., 2019). The study used convenience sampling based on feasibility and ethical consideration.

Pre-experimental Preparation

A 30-minute pre-talk session was held to explain the purpose, significance, and educational value of the experiment. Participants were briefed on the study objectives and provided written informed consent before participation (Kaminsky *et al*., 2019). Each participant completed both exercise protocols (bicycle ergometer and treadmill) with a 7-day washout period between trials to minimize potential carryover effects (Thompson *et al*., 2021). The participants were randomly assigned into two groups: Group A (n=20) undertook the treadmill protocol first, while Group B (n=20) began with the bicycle ergometer protocol. The height, weight, and body mass index (BMI) of all participants were

measured prior to the study. The study protocol received ethical approval from the Institutional Review Board (IRB) (BU/AECPD/2024/012) and the participant data confidentiality was strictly maintained throughout the study.

Procedure

The Lode Corival bicycle ergometer was used for the graded exercise test. Participants began the exercise at a workload of 50 watts, with an incremental increase of 15 watts every 2 minutes until they reached volitional fatigue. A continuous 12-lead ECG (Schiller Inc., Baar, Switzerland) was used to monitor cardiovascular responses throughout the test.

The Bruce treadmill protocol was employed, starting at 2.7 km/h with a 10% incline. Speed and incline were incrementally increased every 3 minutes until maximal exertion was achieved (Wilkins *et al*., 2019). Throughout the exercise, participants' heart rates (HR) were continuously monitored using a Polar heart rate monitor, and blood pressure (BP) was measured at regular intervals using an automated sphygmomanometer.

Data Analysis

Data were collected at baseline (pre-exercise), peak exercise, and post-exercise recovery stages. SPSS version 28 was used for statistical analysis. Descriptive statistics (mean ± standard deviation) were calculated for each parameter. Paired t-tests were used for within-group comparisons between pre- and post-exercise data, while independent t-tests were employed to assess differences between treadmill and bicycle ergometer protocols. $p< 0.05$ was considered statistically significant.

Results

Comparison between Pre- and Post-Exercise Cardiovascular Parameters within Bicycle Ergometer and Treadmill Protocols

Table 1a. shows the pre-and post-exercise cardiovascular responses of participants to Bicycle Ergometer (B.E) and Treadmill (TM) protocols, showing the changes in pulse rate, systolic blood pressure (SYS), diastolic blood pressure (DIA), pulse pressure (PP), and mean arterial pressure (MAP). The average pulse rate for the Bicycle Ergometer group increased significantly from 72.40 ± 11.89 BPM pre-exercise to 92.85 ± 19.82 BPM post-exercise, with a mean difference of 20.45 BPM, while pulse rate for the Treadmill group rose significantly from 92.85 ± 19.82 BPM to 115.75 ± 9.10 BPM, showing a slightly higher mean difference of 22.90 BPM. Both exercise protocols induced significant increases in pulse rate, with the treadmill causing a slightly larger increase. For the Bicycle Ergometer group, systolic blood pressure increased significantly from 116.70 ± 8.20 mmHg to 141.30 ± 12.34 mmHg, with a mean difference of 24.60 mmHg. Systolic blood pressure also rose significantly, from 115.75 ± 9.10 mmHg to 134.20 ± 8.28 mmHg, in the treadmill group, with a mean difference of 19.05 mmHg. Both protocols caused substantial increases in systolic pressure, but the rise was greater with the bicycle ergometer. Diastolic blood pressure for the Bicycle Ergometer group increased significantly from 74.00 ± 8.60 mmHg to 87.55 ± 16.31 mmHg, with a mean difference of 13.55 mmHg, it also rose significantly, from 75.45 ± 8.23 mmHg to 86.95 ± 13.43 mmHg, with a mean difference of 11.50 mmHg in the treadmill group. Both exercise modes elevated diastolic blood pressure, but the bicycle ergometer produced a slightly larger increase. Pulse Pressure increased significantly from 42.70 ± 8.35 mmHg to 53.65 ± 15.39 mmHg, with a mean difference of 10.95 mmHg in the Bicycle Ergometer group, and increase in the treadmill group, though the change from 40.30 ± 12.30 mmHg to 45.90 ± 18.62 mmHg was not statistically significant, with a mean difference of 5.60 mmHg. While both protocols raised pulse pressure, the increase was only statistically significant for the bicycle ergometer protocol.

Mean Arterial Pressure (MAP) showed a significant rise from 88.15 ± 7.54 mmHg to 105.03 ± 13.40 mmHg, with a mean difference of 16.88 mmHg in the Bicycle Ergometer group, and also increased significantly from 88.88 ± 6.26 mmHg to 102.25 ± 9.06 mmHg, with a mean difference of 13.37 mmHg in the treadmill group. Both protocols significantly elevated MAP, with the bicycle ergometer inducing a greater increase. The results in table 1b suggest that while both exercise modalities are effective for cardiovascular stimulation, the bicycle ergometer

appears to elicit a stronger hemodynamic response.

Comparison between Bicycle Ergometer and Treadmill Protocols' Cardiovascular Parameters

The results from the independent sample t-test comparing cardiovascular parameters between the bicycle ergometer and treadmill protocols are shown in table 2. The results indicate that there were no statistically significant differences in cardiovascular parameters, including heart rate, systolic and diastolic blood pressure, pulse pressure, and mean arterial pressure, between the bicycle ergometer and treadmill exercise protocols. This suggests that both exercise modalities have comparable effects on cardiovascular responses in healthy adults under the conditions of this study.

Table 1: Paired T – test Results Comparing Pre and Post – Exercise Cardiovascular Parameters within Bicycle Ergometer and Treadmill Groups (N = 40)

PARAMETER	GROUP	PRE-EXERCISE (MEAN+SD)	POST-EXERCISE (MEAN+SD)	MEAN DIFF.	t – value	p - value
Pulse Rate (BPM)	(B.E)	72.40±11.89	92.85±19.82	20.45	-8.109	0.001*
	(TM)	92.85±19.82	115.75±9.10	22.90	-9.54	0.000*
SYS (mmHg)	(B.E)	116.70±8.20	141.30±12.34	24.60	-20.314	0.011*
	(TM)	115.75±9.10	134.20±8.28	19.05	-6.72	0.001*
DIA (mmHg)	(B.E)	74.00±8.60	87.55±16.31	13.55	-10.14	0.002*
	(TM)	75.45±8.23	86.95±13.43	11.50	-8.45	0.0004*
Pulse Pressure (mmHg)	(B.E)	42.70±8.35	53.65±15.39	10.95	-5.015	0.001*
	(TM)	40.30±12.30	45.90±18.62	5.60	-7.89	0.074
MAP (mmHg)	(B.E)	88.15±7.54	105.03±13.40	16.88	-15.841	0.00013*
	(TM)	88.88±6.26	102.25±9.06	13.37	-10.12	0.0024*

*B.E = Bicycle Ergometer; TM = Treadmill; * = statistically significant difference at p<0.05*

PP (Pulse Pressure) = SYS - DIA; MAP (Mean Arterial Pressure) = DIA + $\frac{1}{3}$PP; mmHg = Millimeter of mercury

Table 2: Independent Sample t– test Results Comparing Cardiovascular Parameters between Bicycle Ergometer and Treadmill Protocols (N = 40)

PARAMETER	BICYCLE ERGOMETER (MEAN+SD)	TREADMILL (MEAN+SD)	MEAN DIFF.	t – value	p - value
		PRE - EXERCISE			
Pulse Rate (BPM)	72.40±11.89	77.65±11.91	-5.25	-1.39	0.890
SYS (mmHg)	116.70±8.20	115.75±9.10	0.95	0.347	0.673
DIA (mmHg)	74.00±8.60	75.45±8.23	-1.45	-0.544	0.492
PP (mmHg)	42.70±8.35	40.30±12.30	2.40	0.722	0.564
MAP (mmHg)	88.15±7.54	88.88±6.26	-0.73	-0.334	0.151
		POST - EXERCISE			
Pulse Rate (BPM)	92.85±19.82	94.35±19.28	0.81	0.831	0.831
SYS (mmHg)	141.30±12.34	134.20±8.28	0.04	0.688	0.688
DIA (mmHg)	87.55±16.31	86.95±13.43	0.90	0.252	0.252
PP (mmHg)	53.65±15.39	45.90±18.62	0.16	0.506	0.506
MAP (mmHg)	105.03±13.40	102.25±9.06	0.45	0.102	0.102

*PP (Pulse Pressure) = SYS - DIA; MAP (Mean Arterial Pressure) = DIA + $\frac{1}{3}$PP; mmHg = Millimeter of mercury; * = statistically significant difference at p<0.05*

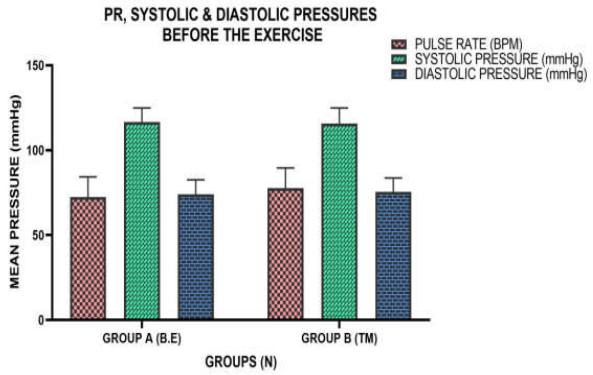

Figure 1a: Simple Bar Chart showing the Pre-Exercise Pulse Rate, Systolic and Diastolic Blood Pressures for Bicycle Ergometer and Treadmill Protocol Groups

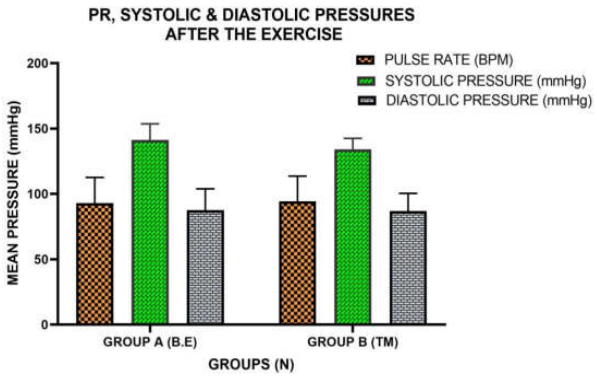

Figure 1b: Simple Bar Chart showing the Post – Exercise Pulse Rate, Systolic and Diastolic Blood Pressures for Bicycle Ergometer and Treadmill Protocol Groups

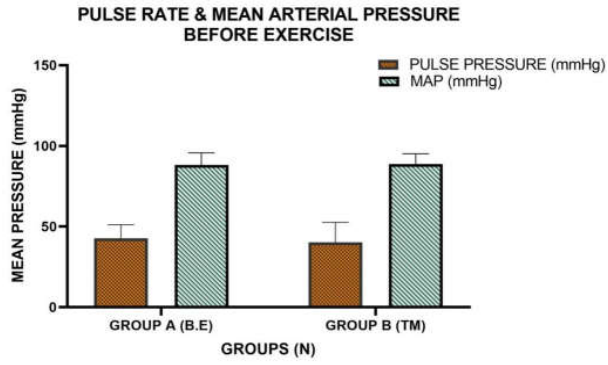

Figure 2A: Simple Bar Chart showing the Pre-Exercise Pulse Pressure and Mean Arterial Pressure for Bicycle Ergometer and Treadmill Protocol Groups

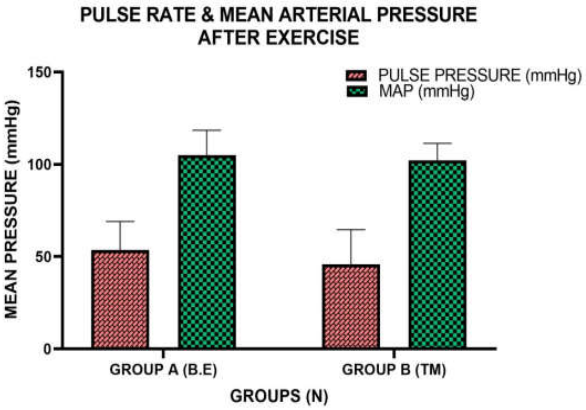

Figure 2B: Simple Bar Chart showing the Post-Exercise Pulse Pressure and Mean Arterial Pressure for Bicycle Ergometer and Treadmill Protocol Groups

Discussion

The present study evaluated the comparative effect of bicycle ergometer and treadmill exercise on cardiovascular parameters among Nigerian men in Abuja. The findings indicate significant changes in key cardiovascular indices, including pulse rate, systolic blood pressure (SP), diastolic blood pressure (DP), pulse pressure (PP), and mean arterial pressure (MAP) following both exercise modalities. These findings align with previous studies demonstrating the hemodynamic effects of aerobic exercise on cardiovascular function (American College of Sports Medicine (ACSM), 2018; Marshall *et al*., 2025). The increase in pulse rate observed in both exercise protocols is expected, as aerobic exercise typically induces an elevated heart rate to meet the increased oxygen demand of working muscles (Guyton & Hall, 2020). The pulse rate increase was slightly higher in the treadmill groups compared to the bicycle ergometer group, suggesting a greater cardiovascular demand during treadmill exercise. This result is consistent with prior research indicating that weight-bearing exercises, such as treadmill running, generally require higher cardiac output than non-weight-bearing exercises like cycling (McArdle *et al*., 2018). The increase in systolic blood pressure in both groups reflects the increased cardiac workload associated with aerobic exercise. However, the greater increase observed in the bicycle ergometer group suggests a potentially

higher peripheral vascular resistance during cycling. This observation is in line with studies indicating that cycling may induce greater systemic vascular resistance due to prolonged isometric contractions of the lower limbs (Fagard, 2001). Diastolic blood pressure also increased significantly in both groups, albeit to a slightly greater extent in the bicycle ergometer group. This finding supports the notion that different exercise modalities elicit varied autonomic and vascular responses (Pescatello *et al*., 2019). Pulse pressure, an indicator of arterial stiffness and cardiovascular risk, showed a significant increase in the bicycle ergometer group, whereas the increase in the treadmill group was not statistically significant. The greater pulse pressure response in the bicycle ergometer group suggests a more pronounced arterial compliance challenge, potentially due to the sustained muscle contractions required during cycling (Franklin *et al*., 2008). Mean arterial pressure (MAP) also showed significant elevations in both groups, with the bicycle ergometer inducing a greater increase. This aligns with evidence indicating that cycling may elicit a more substantial pressure response due to increased vascular resistance and muscle pump mechanisms (Cornelissen & Smart, 2013). Despite the within-group differences observed, the independent sample t-test revealed no statistically significant differences in cardiovascular parameters between the bicycle ergometer and treadmill protocols. This suggests that both exercise modalities produce comparable cardiovascular effects in healthy individuals under the study conditions. These results concur with previous studies demonstrating that while different aerobic exercises have unique hemodynamic profiles, their overall cardiovascular benefits remain similar when matched for intensity and duration (Cornelissen & Smart, 2013).

The limitations of this study arise from its relatively small sample size (N = 40) which limit the generalizability of the findings. Additionally, factors such as individual fitness levels, exercise intensity variations, and autonomic responses were not extensively controlled. Future studies should consider larger cohorts, diverse population groups, and the inclusion of additional cardiovascular markers such as heart rate variability and endothelial function to provide a more comprehensive understanding of the physiological responses to different exercise modalities.

Conclusion

In conclusion, both bicycle ergometer and treadmill exercises significantly improve cardiovascular parameters, with minor differences in the magnitude of response. While the bicycle ergometer elicited slightly higher systolic blood pressure, pulse pressure, and mean arterial pressure responses, treadmill exercise resulted in a marginally greater pulse rate increase. The findings from this study suggest that treadmill exercise benefit the cardiovascular system (blood pressure and mean arterial pressure) compared with biocycle ergometer.

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Declaration of Competing Interest

The authors declare that there are no known financial or non-financial competing interests or personal relationships that could have influenced the conduct, outcomes, or interpretation of this research.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the author(s) used ChatGPT (developed by OpenAI) in order to improve clarity, grammar, and overall language quality. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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