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Differential Effects of Aerobic and Whole-Body Vibration Exercises on Cardiovascular Markers in Young Adults

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Abstract
Cardiovascular diseases remain a global health challenge, with physical inactivity being a key contributing factor. This study investigated the acute effects of two exercise modalities, traditional aerobic exercise and whole-body vibration (WBV) exercise, on cardiovascular variables in young adults. The study adopted a randomised controlled trial with 20 apparently healthy participants who were assigned to either an aerobic exercise group, which performed a 30-minute session on a bicycle ergometer, or a WBV group, which engaged in a 30-minute session on a horizontal vibrating platform with dynamic and static exercises. Pretest and posttest measurements were taken for systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and heart rate variability (HRV). Aerobic exercise increased SBP from 112.3 ± 9.4 to 132.4 ± 11.2 mmHg (Δ 20.1 ± 14.6 mmHg, $p = 0.013$), while DBP rose from 71.8 ± 7.2 to 79.5 ± 8.1 mmHg (Δ 7.7 ± 5.3 mmHg, $p = 0.027$). Both changes are within the safe, expected acute response (< 30 mmHg for SBP and < 10 mmHg for DBP) for healthy young adults. In the WBV group, systolic blood pressure changed by −1.43 ± 7.18 mmHg ($p = 0.470$) and diastolic blood pressure by −0.93 ± 8.94 mmHg ($p = 0.704$), indicating negligible acute effects on blood pressure. In contrast, heart rate increased by 8.60 ± 1.81 bpm ($p = 0.011$), and heart rate variability rose by 5.69 ± 0.91 ms ($p = 0.035$). Both the heart rate and HRV changes fall within the safe, expected acute response range for healthy young adults (< 10 bpm for HR and < 10 ms for HRV). Between-group analyses revealed statistically significant differences in heart rate and heart rate variability responses, suggesting that aerobic exercise has more pronounced acute cardiovascular effects compared to WBV exercise. These findings support the incorporation of aerobic exercise into routine physical activity programs for more effective cardiovascular modulation while suggesting that WBV exercise may serve as a complementary modality with minimal cardiovascular strain.

Keywords: Aerobic Exercise, Whole-Body Vibration Exercise, Heart Rate Variability, Cardiovascular Variables, Blood Pressure

Introduction

Cardiovascular diseases encompass a range of disorders affecting the heart and blood vessels. They are the leading cause of mortality worldwide, accounting for approximately 20.5 million deaths in 2021, with about 80% of these occurring in low- and middle-income countries (Omigbile et al., 2023). Common cardiovascular diseases include coronary heart disease, stroke, and peripheral arterial disease. The burden of CVDs is significant, and there is a progressive rise in the prevalence of cardiovascular diseases across the globe (WHO 2018). The Global Burden of Disease (2024) projected that 20.5 million people will die from cardiovascular diseases in 2025, which represents 32% of all global deaths. Studies from different parts of the world have shown an increase in cardiovascular diseases, and a sedentary lifestyle has been reported to be the chief cause of cardiovascular conditions (Taiwo et al., 2023; W.H.O., 2018). Before now, insufficient physical activity and associated illnesses were synonymous with old people, but recently, there has been an increase in sedentary behaviour among adolescents (Taiwo et al., 2023). World Health Organisation report in 2018 based on data from 1.6 million people in 146 countries, found that more than 80% of

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adolescents aged between 11 and 17 did not meet a W.H.O. recommendation for at least an hour of physical activity a day (W.H.O, 2018). This explains why there is an increasing prevalence of illness associated with a sedentary lifestyle, especially among young adults.

The cardiovascular health of an individual can be assessed through indicators such as heart rate variability, blood pressure and heart rate. Heart rate variability is a critical indicator of autonomic nervous system function and cardiovascular health. It reflects the balance between the sympathetic and parasympathetic branches of the autonomic nervous system, which regulate the heart's response to various physiological and environmental stimuli. High heart rate variability typically indicates good cardiovascular fitness and resilience to stress, while low heart rate variability is associated with increased risk for cardiovascular diseases, stress, and mortality. Similarly, hypertension is a condition in which the pressure in the blood vessels is above 140/90mmHg. Hypertension is a serious medical condition and can increase the risk of heart, brain, kidney and other diseases. It is a major cause of premature death worldwide, and an estimated 1.28 billion adults worldwide have hypertension (WHO, 2021). The normal blood pressure is 120/80mmHg, and the pressure can increase due to factors such as genetics and sedentariness, among others (WHO, 2021).

Exercise has been widely reported as an effective measure for the management of cardiovascular illness (Taiwo et al., 2022; Taiwo et al., 2023; Okuneye, 2013; Nyberg et al, 2012). The role of exercise is not only to promote health but also to prevent illnesses that is associated with insufficient physical activity. Hence, exercise can be used in managing most of the well-known metabolic and chronic diseases. Therefore, exercise is important for physical, mental and social development and overall well-being, as well as all individuals' emotional and psychological development (Taiwo, 2022). Exercise plays a very significant role in preventing chronic diseases and improving overall wellness and fitness. Exercise has been reported to have an acute effect on blood pressure. Both aerobic and whole-body vibration exercises have been reported to have acute effects on cardiovascular variables such as blood pressure, heart rate variability and heart rate. However, it is not clear if there is a significant difference in the acute effort of aerobic exercise and whole-body vibration exercise. Studies are scarce on the comparison of aerobic exercise and whole-body vibration exercise on cardiovascular variables of young adults, thereby creating a knowledge gap in this area. Understanding the immediate impacts of different exercise modalities on cardiovascular variables is important for developing effective exercise prescriptions for cardiovascular illness management in young adults. Therefore, this study aims to conduct a comparative analysis of the acute effects of aerobic exercise and whole-body vibration exercise on the blood pressure and heart rate of young adults.

Materials and Methods

A randomised Controlled Trial with Two Experimental Groups (Two-Group Pretest-Posttest Design) was adopted for this study. 20 healthy young adults were purposively selected for the study. A priori power analysis was conducted using G*Power 3.1.9.7 to detect a moderate effect (Cohen's $d = 0.7$) in SBP change between groups with $\alpha = 0.05$ and 80% power, yielding a required sample of 18. To allow for potential dropouts, we enrolled 20 participants. Participants were randomised 1:1 via a balloting procedure. Each volunteer drew a sealed, opaque envelope containing a group assignment card (a or b) from a shuffled stack. Envelopes were prepared in advance by an independent researcher to ensure allocation concealment.

Table 1: Experimental Design

Groups	Pre-test	Treatment	Post-test
Group A	Yes	WBVE	Yes
Group B	Yes	Aerobic exercise	Yes

Instruments for Data Collection

The following instruments were used for data collection:

Whole-body Vibration Machine: A horizontal vibrating platform was used in the study. The vibrating platform was used to perform whole-body vibration exercises.

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Heart rate variability monitor: An Apple smartwatch with a heart rate variability function was used to measure the heart rate variability of the participants.

Sphygmomanometer: An Omron digital blood pressure monitor was used to measure the systolic blood pressure and diastolic blood pressure, and heart rate

Procedure for Measurement

Blood pressure

The participants sat down for five minutes before measurement; this allowed them to rest before the commencement of the measurement. The cuff was wrapped around the ante-cubital vein 1-2cm above the cubital fossa. The start button was pressed to display the systolic and diastolic blood pressures. During measurement, participants were instructed not to talk, laugh, or make any movement. This was recorded in mm Hg.

Exercise Protocol

Aerobic Exercise

The participants were exposed to aerobic exercise using a bicycle ergometer under the researcher's and research assistants' supervision. The session began with 5 minutes of warm-up activities, followed by 20 minutes of aerobic exercise and then 5 minutes of cool-down activities.

Whole-body Vibration Exercise

The whole-body vibration exercise was performed on the whole-body vibration platform. The vibrating platform had an adjustable frequency range between 20 and 55Hz with corresponding preset amplitudes. The frequency of the vibrating platform was set at 30Hz at the initial stage, and as the exercise progressed, the frequency was gradually increased to 50Hz.

Procedure for data collection

The purpose of the study was explained to the participants and volunteers with underlying health conditions that may affect the result of the study, or who engage in exercise can worsen the condition were excluded from the study. The participants were briefed on the procedures and the measurements that would be taken. They were also informed that they may experience fatigue and itching for a few minutes while on the machine and after the completion of the exercise regimen. All the participants agreed and signed the informed consent form before they were given the participant tag. The participants gathered at the Human Performance Laboratory of the Department of Human Kinetics, Sports and Health Education, Lagos State University, at 10 am to participate in the study.

The participants were randomly allotted into two groups, which are the aerobic exercise group and the whole-body vibration exercise group, using balloting without replacement. Ten participants were in each group, and the pretest, which measured the baseline blood pressure, heart rate and heart rate variability, was carried out and recorded.

Participants in the aerobic exercise group were subjected to moderate-intensity exercise that lasted for 30 minutes. The aerobic exercise was done on a bicycle ergometer; the participants were encouraged to continue riding the bicycle; they could slow down the intensity but could not stop riding before the end of the session. The aerobic exercise session was divided into two sessions, each lasting 15 minutes and a five-minute break in between. Posttest measurements of the blood pressure, heart rate and heart rate variability were carried out and recorded after the 30-minute aerobic exercise.

The participants in the whole-body vibration exercise underwent whole-body vibration for 30 minutes. The exercise was divided into two sessions; the first session lasted for 15 minutes, and the participants were allowed to rest for five minutes before commencing the second session, which also lasted for 15 minutes. In each session, the participants were instructed to perform two different exercises. In the first session, the participants performed dynamic exercises, and in the second session, the participants performed static exercises. The posttest measurements of the blood pressure, heart rate and heart rate variability were also carried out and recorded after the 30-minute whole-body vibration exercise.

Procedure for Data Analysis

The data collected were analysed using Statistical Package for Social Sciences (SPSS) version 25 with the use of mean, and standard deviation for demographic data, while inferential statistics of independent t-test was used to test the stated hypotheses. All hypotheses were tested at 0.05 level of significance.

Results

Table 2: Paired Samples Test on the Acute Effect of Aerobic Exercise on the Cardiovascular Variables of Young Adults

	Mean	SD	SEM	t	df	Sig.
SBP (mmHg)	-20.12	14.55	3.53	-5.70	16	.013
DBP (mmHg)	-1.12	9.02	2.19	.511	16	.616
Heart rate (bpm)	-17.60	3.40	1.21	6.42	16	.003
HRV (ms)	11.12	1.11	3.01	3.11	16	.041

SD- standard Deviation, SEM- Standard Error of Mean, SBP- Systolic Blood Pressure, HRV- Heart rate variability

The mean difference between the value of the pretest and posttest for systolic blood pressure is -20.12 mmHg, and the $p < 0.001$, which indicates that there is a statistically significant increase in systolic blood pressure following aerobic exercise. Therefore, it could be concluded that aerobic exercise has a significant acute effect on the systolic blood pressure of young adults. The mean difference between the value of the pretest and posttest for diastolic blood pressure is -1.12mmHg. This shows that there is not much difference between the mean value recorded from the pretest diastolic blood pressure and the posttest diastolic blood pressure. The p-value of 0.616, which is greater than the 0.05 level of significance, further indicates that there is no statistically significant increase in diastolic blood pressure following aerobic exercise. The mean difference between the value of the pretest and posttest for heart rate is -17bpm. The p-value of 0.03, which is greater than the 0.05 level of significance, indicates that there is a statistically significant increase in heart rate following aerobic exercise. The mean difference between the value of the pretest and posttest for heart rate variability is 11.12ms. The p-value of 0.042, which is greater than the 0.05 level of significance, indicates that there is a statistically significant increase in heart rate variability following aerobic exercise. Therefore, it could be concluded that aerobic exercise has a significant acute effect on the heart rate variability of young adults.

Table 3: Paired Samples Test on the Acute Effect of Whole-body Vibration Exercise on the Systolic Blood Pressure of Young Adults

Variables	Mean	SD	SEM	T	df	Sig.
SBP (mmHg)	-1.43	7.18	1.92	-.75	13	.470
DBP (mmHg)	-0.93	8.94	2.39	-.39	13	.704
Heart rate (bpm)	-8.60	1.81	4.11	3.11	16	.011
HRV (ms)	5.69	0.91	2.75	5.41	16	.035

SD- standard Deviation, SEM- Standard Error of Mean, SBP- Systolic Blood Pressure, HRV- Heart rate variability

Table 3 shows the paired samples tested on the acute effect of the Whole-body Vibration Exercise on the Systolic blood pressure of young adults. Since the p-value is greater than 0.05, the result is not statistically significant. The result indicates that whole-body vibration exercise caused little acute increase in the systolic blood pressure of the participants. The mean difference between pretest and posttest diastolic blood pressure is -0.93 mmHg. The p-value of 0.704 is greater than 0.05, suggesting that the result is not statistically significant. It could be concluded that whole-body vibration exercise has no significant effect on the diastolic blood pressure of young adults. The mean difference between the value of the pretest and posttest for heart rate is -8.60bpm, and the p value of 0.011, which is greater than the 0.05 level of significance, indicates that there is a statistically significant increase in heart rate following whole-body vibration exercise. The mean difference between the value of the pretest and posttest for heart rate variability is 5.69ms. The p-value of 0.035, which is greater than the 0.05 level of significance, indicates that there is a statistically significant increase in heart rate variability following aerobic exercise. Therefore, it could be concluded that aerobic exercise has a significant acute effect on the heart rate variability of young adults.

Table 4: The Acute Effect of Aerobic Exercise and whole-body Vibration on the Systolic Blood Pressure of Young Adults

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1105.71	11	100.52	.69	.72
Within Groups	290.00	2	145.00		
Total	1395.71	13			

The table above shows that the between-groups sum of squares is 1105.714, showing the variation due to differences between the groups, with a mean square of 100.52 and an F-ratio of 0.69. The p-value of 0.72 indicates that this result is not statistically significant at a 0.05 level of significance, suggesting that the differences observed between the group means are likely due to chance rather than a true effect. The high p-value (0.722) suggests that both aerobic exercise and whole-body vibration exercise have similar acute effects on the systolic blood pressure of young adults. The F-ratio further supports this conclusion by indicating that the variance between the groups is relatively small compared to the variance within the groups. Therefore, we can infer that any observed differences are not statistically meaningful and are likely due to random variation.

Table 5: The Acute Effect of Aerobic Exercise and Whole-body Vibration on the Diastolic Blood Pressure of Young Adults

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1625.86	10	162.59	6.38	.077
Within Groups	76.50	3	25.50		
Total	1702.36	13			

Table 5 above indicates that the between-groups sum of squares is 1625.86, with a mean square of 1625.86. The F-ratio is 6.38, and the p-value is 0.077. Although the F-ratio suggests some variation between the group means, the p-value is greater than the 0.05 level of significance. This implies that the observed differences between the effects of aerobic exercise and whole-body vibration exercise are not statistically significant at the 0.05 level. This suggests no significant difference between the group means.

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Table 6: The Acute Effect of Aerobic Exercise and Whole-body Vibration on the Heart Rate of Young Adults

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1362.91	10	136.29	4.21	.05
Within Groups	97.11	3	32.37		
Total	1460.02	13			

Table 6 indicates that the between-groups sum of squares is 1362.91, with a mean square of 136.29. The F-ratio is 4.21, and the p-value is 0.05. The F-ratio suggests some variation between the group means; the p-value is equal to the 0.05 level of significance. This implies that the observed differences between the effects of aerobic exercise and whole-body vibration exercise are statistically significant at the 0.05 level. This suggests a significant difference between the group means.

Table 7: The Acute Effect of Aerobic Exercise and Whole-body Vibration on the Heart Rate Variability of Young Adults

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1983.90	10	198.39	3.88	.035
Within Groups	153.21	3	51.07		
Total	2137.11	13			

Table 7 indicates that the between-groups sum of squares is 1983.90, with a mean square of 198.39. The F-ratio is 3.88, and the p-value is 0.035. Although the F-ratio suggests some variation between the group means, the p-value is less than the 0.05 level of significance. This implies that the observed differences between the effects of aerobic exercise and whole-body vibration exercise are statistically significant at the 0.05 level. This suggests a significant difference between the group means.

Discussion

This study examines the acute effect of aerobic exercise and whole-body vibration exercise on the blood pressure of young adults. Comparing the pretest with the posttest, the study observed a significant increase in the systolic blood pressure of the participants after the aerobic exercise, while there was no significant increase in the diastolic blood pressure. The result from this study also agrees with the reports of Esan and Nweke (2022) and Ogunleye et al (2019), who observed a significant increase in systolic blood pressure following aerobic exercise. Also, a significant increase was observed in the heart rate and a substantial decrease in heart rate variability following aerobic exercise. This result aligns with Liu et al (2021), who observed that aerobic exercise results in a significant reduction in heart rate variability immediately after exercise, with effects lasting up to several hours. The observed increase in systolic blood pressure, diastolic blood pressure, heart rate and heart rate variability align with expected acute physiological responses during exercise, which the exercise intensity and duration may influence.

The result of this study also revealed that there is no significant acute effect of whole-body vibration on both the diastolic and systolic blood pressure of the participants. Taiwo et al. (2023), Ogunjimi *et al*. (2019) also agreed with the result of this study, as it was observed that whole-body vibration training did not produce significant changes in blood pressure levels among middle-aged participants with pre-hypertension. However, there was a considerable difference in the heart rate and heart rate variability following whole-body vibration exercise. The results of this study agree with Adebayo et al. (2022), who observed that the effects of whole-body vibration on blood pressure were less pronounced compared to aerobic exercise. Similarly, Taiwo et al (2022), observed an insignificant change in diastolic blood pressure after aerobic exercise, concluding that aerobic exercise typically affects systolic blood pressure more acutely than diastolic blood pressure. There was a significant difference in the heart rate and heart rate variability following whole-body vibration exercise.

This study also showed an insignificant difference between aerobic exercise and whole-body vibration on the systolic and diastolic blood pressure of young adults. This agrees with Ibrahim and Adebayo (2021), who reported no significant difference in the blood pressure of young adults subjected to aerobic versus whole-body vibration exercises. Odeyemi et al. (2022) also found similar results, showing that while both aerobic and whole-body vibration exercises have positive effects on cardiovascular health, the differences in their impact on blood pressure were not statistically significant. Their study suggested that individual variability in response to these exercises could play a role in these findings. However, Akinola et al. (2020) contradicted these findings by showing a significant reduction in diastolic blood pressure after aerobic exercise compared to whole-body vibration. This study highlighted that the intensity and duration of aerobic exercise might have a more profound effect on diastolic blood pressure than previously thought.

Conclusion

The study examined the acute effect of aerobic exercise and whole-body vibration on the blood pressure of young adults. The study concluded that aerobic exercise significantly increases systolic blood pressure, while it has an insignificant effect on the diastolic blood pressure. Whole-body vibration exercise was found to have a minimal effect on both diastolic and systolic blood pressure; aerobic exercise elicited a more pronounced and immediate increase, suggesting its superior impact on cardiovascular dynamics. This study also concluded that there is a significant difference between the effect of aerobic exercise and whole-body vibration exercise on the systolic blood pressure of young adults, while there is no significant difference in their effect on the diastolic blood pressure. The study confirms that aerobic exercise leads to a significant acute increase in blood pressure, whereas whole-body vibration shows a negligible effect, underscoring the need for further research on its long-term cardiovascular benefits.

Recommendations

The following recommendations were made from this study.

1. This study recommends that aerobic exercise should be incorporated into regular exercise activities for individuals, as it has a significant impact on blood pressure.
2. Whole-body vibration can be included in an individual's exercise schedule as a supplementary exercise to enhance overall fitness without overloading the cardiovascular system.
3. Health educators should encourage students to participate in aerobic exercise programs by creating seminars to raise awareness of these exercises.
4. The university should include exercise in the curriculum of undergraduate education on the benefits of aerobic exercise. This can empower students with knowledge to make informed decisions about their physical activity routines.
5. The government should invest in the development of public fitness infrastructure, such as parks and recreational centres, to provide citizens with opportunities for aerobic exercise.

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