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The Blood Pressure and Pulse Rate Responses to Isometric Handgrip Exercise and the Effects of Variation of the Duration and Intensity of the Exercise Protocol in Prehypertensive Patients

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Keywords: Isometric Handgrip Exercise; Prehypertension; Blood Pressure; Pulse Rates; Maximum Voluntary Contraction; Duration; Intensity of Exercise

Abbreviations: IHG: Isometric Handgrip; MVC: Maximum Voluntary Contraction

ABSTRACT

Background: Research evidence suggests that isometric exercise induces an exaggerated blood pressure (BP) response. However, the effects of intensity and duration of the isometric exercise protocols on blood pressure response have not been extensively studied.

Aims: To assess the responses of the BP and pulse rate (PR) to isometric handgrip exercise at 30% Maximum Voluntary Contraction (MVC) and establish the effects of variation of the isometric handgrip exercise protocol on the BP and PR in prehypertensive patients.

Methods: A pragmatic randomized controlled trial design was used. The sample was 256 sedentary prehypertensive adults (exercise [n =192] and control [n = 64)] groups), aged between 30-50 years. The control group was placed on lifestyle modification only, while the exercise group performed a 24 consecutive days' isometric handgrip exercise at 30% MVC in addition to a lifestyle modification. The outcome measures were changes in BP and PR at baseline, after 24 days and 48 after days.

Results: At the end of the 24 consecutive days, there was a statistically significant reduction in BP in favour of the exercise group (p<0.001). Furthermore, after 48 days, cessation of the exercise protocol after 24 days resulted in a significant reduction of BP and PR (p<0.001) however, the variables did not return to the baseline levels at 24 days' post exercise. Increase in MVC from 30% to 50% resulted in a significant reduction of BP.

Conclusion: This study has demonstrated that isometric handgrip exercise was effective strategy in the attenuation of BP in individuals with prehypertension especially when combined with the routinely recommended lifestyle modifications. It has also established that increase in the intensity of the exercise protocols produced more beneficial results compared with increase in exercise duration.

Introduction

The World Health Organization (WHO) estimates that cardiovascular diseases will account for up to 40% of all deaths worldwide [1]. Hypertension is a significant risk factor with subsequent target organ damage for cardiovascular diseases [2]. Hypertension is estimated to affect over one billion adults worldwide with this number projected to increase to 1.56 billion in 2025 [3-5]. It causes significant morbidity and mortality worldwide and it is one of the major causes of stroke, kidney disease and cardiac failure [6,7]. It has been shown to be responsible for one in every eight deaths and as many as 7 million deaths annually thereby constituting a major socioeconomic burden all over the world [8]. Since over 60% of the world population is affected by it, it has posed a serious challenge in terms of its prevention and management. Despite the increased knowledge for the need to prevent hypertension and the claims of the availability of various forms of anti-hypertensive agents, the disease it still on the rise and remains a huge health and economic challenge [9]. Research evidence have shown that there is a high rate of progression to hypertension among individuals with prehypertension, and this is linked to an increased risk of cardiovascular diseases and cardiovascular events such as stroke and death [2]. The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of high BP reported that prehypertension accounts for 62 percent of cerebrovascular disease and 49 percent of ischemic heart disease" [2].

The risks are higher in people ranging from 40 to 89 years of age. It is reported that every 20mmHg systolic or 10mmHg diastolic rise in BP results in doubling of mortality rate. Therefore, if the rise in BP with age could be prevented or diminished, the risk factors associated with hypertension such as cardiovascular and renal diseases, might be prevented. Since the risk of developing hypertension is very high, a public health strategy, that will reduce the chances of developing it, is not only needed but very important. Isometric hand grip exercise is one promising treatment that is currently being explored as a remedy [3,10]. Physical activity has been shown to have an independent long-term action of lowering BP and has therefore been recommended as a prophylactic non-pharmacological agent in the management of hypertension [1,2,3,8,11]. However, evidence on the recommendations for isometric exercise as a means of lowering hypertension is scarce. Wiles et al., stated that, there are currently no definitive positional statement or recommendation guidelines for the use of isometric exercise as part of the management of hypertension [12]. Several scientific studies clearly demonstrates that isometric exercise training is capable of lowering resting BP both in normotensive and hypertensive individuals [1,3,8,12]. A meta-analysis by several authors has shown that isometric exercise produced greater reductions in systolic and diastolic BP compared to dynamic exercise training because dynamic exercise is physically demanding, cumbersome and lacks objective quantification so difficult to prescribe [10,13]. These challenges have made compliance to dynamic exercises very difficult.

Besides, isometric exercise has been shown to be comparable to dynamic exercise in the development of muscle bulk, intramuscular and peak rate of tension, muscle strength and endurance [12]. Furthermore, some of the advantages of isometric exercise include ease of access, easy to use and it enables individuals especially those with co-morbidities that may restrict movement capacity to participate. Notable aspects of isometric handgrip exercise are that it can be performed quickly, easily, and in any location with less concentration. These attributes may enhance compliance thereby increasing the probability of positive clinical outcomes in prehypertensive individuals. However, previous studies on effect of isometric handgrip exercise on hypertensive individuals have methodological issues such as major design flaws, lack of standardization of training procedures and quantification of exercise. Therefore, it is difficult to have conclusive evidence on the parametric effects of isometric exercise in the management of hypertension. The American Heart Association categorizes isometric exercise as having Level of Evidence C for BP-lowering efficacy in contrast to aerobic and dynamic resistance exercise with levels of evidence A and B, respectively [14]. This study therefore investigated the effects of cessation, continuation and increase in the intensity of isometric handgrip exercise on the BP and pulse rate of individuals with prehypertension.

Research Question

What are the effects of cessation, continuation and increase in the intensity of isometric handgrip exercise on the BP and pulse of individuals with prehypertension?

Materials and Method

The study consisted of an isometric handgrip exercise group and a control group. Two hundred and fifty-six prehypertensive individuals (n = 256, males =140 and females =116, age, 39.04±6.4 years; body mass index, 25.45 ± 2.72 kg/m^2), were recruited for the study. Inclusion into the study was subject to a normal cardiovascular examination, determined by a consultant cardiologist. All the participants were diagnosed and referred by the physician with a BP level classified as prehypertension based on the classification of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High BP [2]. This represents a systolic BP range of 120-139 mmHg and diastolic BP range of 80-89 mmHg. Only subjects, with no clinical evidence of other cardiovascular disease such as stroke, diabetes or complications of hypertension were recruited. Participants were included if they had not been treated for hypertension and were not on any medication for hypertension. The subjects were properly briefed about the study and written informed consent was obtained before they were recruited into the study. Subjects were excluded if their age is below or above 40 ± 10 years or have a BP above or below the prehypertension level or a queried health status with clinical evidence of other cardiovascular diseases or diabetes mellitus or on hypertensive medications. Other exclusion criteria for Isometric Hand Grip exercise include individuals suffering from debilitating arthritis, carpel tunnel, peripheral neuropathy, an aneurysm, or mitral valve complications.

This study further conformed to the Declaration of Helsinki and jointly received institutional ethical approval from the Federal Medical Centre Asaba Delta State (FMC/ASB/A81.VOLXII/101) and Faculty of Basic Medical Sciences, Delta State University, Abraka, Delta State, Nigeria (REC/FBMS/DELSU/18/16/103). A screening session was conducted to assess the BP of potential candidates. All BP measurements were taken using the American College of Cardiology American Heart Association (2019) guideline for BP measurement14, which requires each subject to rest in a quiet environment for at least 10 minutes prior to BP measurement. The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High BP (JNC7, 2003), classification guideline was used primarily because it highlighted the inherent risks associated with the category of prehypertensive population and emphasized the need for intervention in that population. Secondarily, this work is a follow up on previous studies that had been done in related area and the need for uniformity was important [15]. On arrival at the clinic, the subjects were made to observe a 15-minute seated rest with their back supported, legs uncrossed. The position adopted by the subjects' during measurement was upright position in a chair with the arms supported on a table. The cuff was wrapped around the left arm of the subjects above the level of the cubital fossa and fastened properly not allowing a space of more than two finger breaths.

The participants were randomised into two groups, the exercise (n=192) and control (n=64) groups, using concealed allocation. The subjects were asked to pick from a ballot box, concealed papers marked "EG" or "CG" on it, designating exercise or control group respectively, to determine which group the subjects should belong. Following the picking of each paper, the chief investigator assigned the patient to either the exercise or control group, using the label EG or CG on the marked paper. Through such a process, every participant had an equal opportunity of being allocated to the exercise or control group, thus minimizing systematic bias. Although participants were blinded to the study allocation, it was not possible to blind the chief investigator who gave the training on lifestyle modifications and isometric hand grip exercise and was also the outcome assessor. Although this could have introduced bias into the study, the outcome measures - BP and PR readings were taken using automated machine to minimize measurement bias. The control group observed a lifestyle modification and compliance was monitored for 24 days, while the exercise group engaged in an isometric hand grip training in addition to a lifestyle modification. The exercise protocol involved 24 consecutive days, brief sub-maximal isometric hand grip exercise training. The BPs of both groups were collected for analysis.

Procedure

The procedures involved the study of the medical case notes and assessment of the subjects. Detailed assessment was carried out to determine environmental factors that influenced BP in each subject and the resting values of their cardiovascular parameters obtained. A brief lecture on the need to adopt healthy lifestyles was given and the particular lifestyle change needed in each patient was recommended. Compliance to lifestyle modifications was seriously emphasized and monitored. The subjects were consequently randomly distributed into the exercise and control groups. The 64 participants that constituted the control group observed a modification of their lifestyles (such as diet – reduction of salt intake) only, while the participants that constituted the exercise group participated in isometric handgrip exercise at 30% maximum voluntary contraction (MVC) for 24 consecutive days in addition to a modification of their lifestyles. At the end of 24 days the resting cardiovascular parameters were recorded on the 25th day. Following the completion of the exercise protocol on the 24th day, the exercise group (EG) was further subdivided into three groups namely, exercise group one (EG1), exercise group two (EG2) and exercise group three (EG3). The exercise group one (EG1) discontinued with the exercise protocol after 24 consecutive days while the exercise group two (EG2) continued for another 24 consecutive days at 30% MVC and the exercise group three (EG3) continued for another 24 consecutive days at 50% MVC. At the end of the 24 days, the resting data of the systolic and diastolic BPs and PRs was collected. Details of participant flow through the study are shown in Figure 1.

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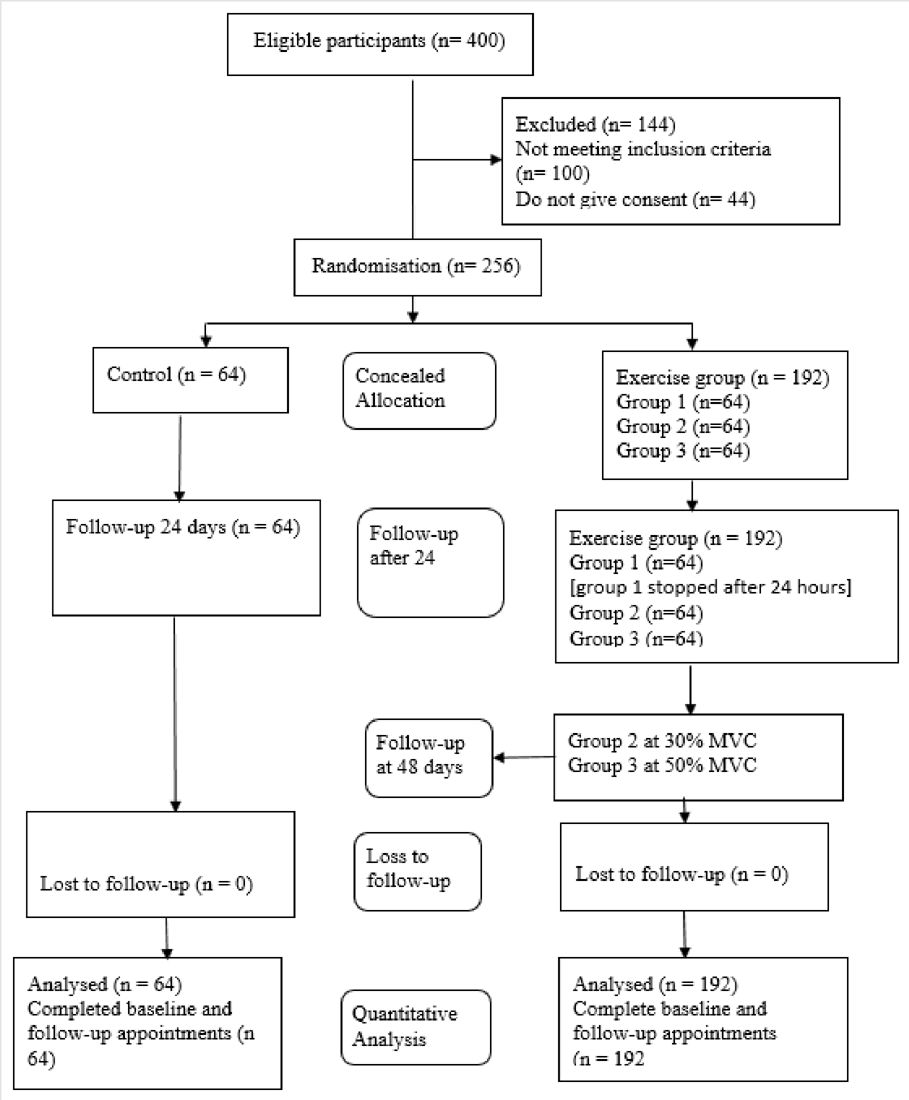

Figure 1: Flow Diagram Showing Movement of the Patient through the Trial.

The Exercise Protocol

A detailed explanation and a demonstration of the exercise protocol were given to the subjects by the chief investigator, and they were asked to report at the Physiotherapy clinic at 4.00 pm, for the exercise daily. The training session for each day took place between the hours of 4.00 pm and 8.00 pm daily. The subjects on arrival at the clinic were made to observe a 15-minute seated rest after which their cardiovascular parameters were measured (Figures 2-4). The subjects were then asked to squeeze the dynamometer with their dominant hand twice, for a maximum of 2 seconds with a five minutes' rest in between; so as to determine their respective MVC for each session. The mean of the two readings was taken as the MVC for each subject for that session. Subjects were thereafter instructed to squeeze and sustain the dynamometer for 2 minutes at 30% MVC. The dynamometer pointer which read the scale gave visual feedback to the subjects for the maintenance of the 30% MVC. This procedure was repeated twice for each training session with a 5 minutes' rest in between. The position adopted by the subjects throughout the exercise training was sitting with upper limbs supported on a table.

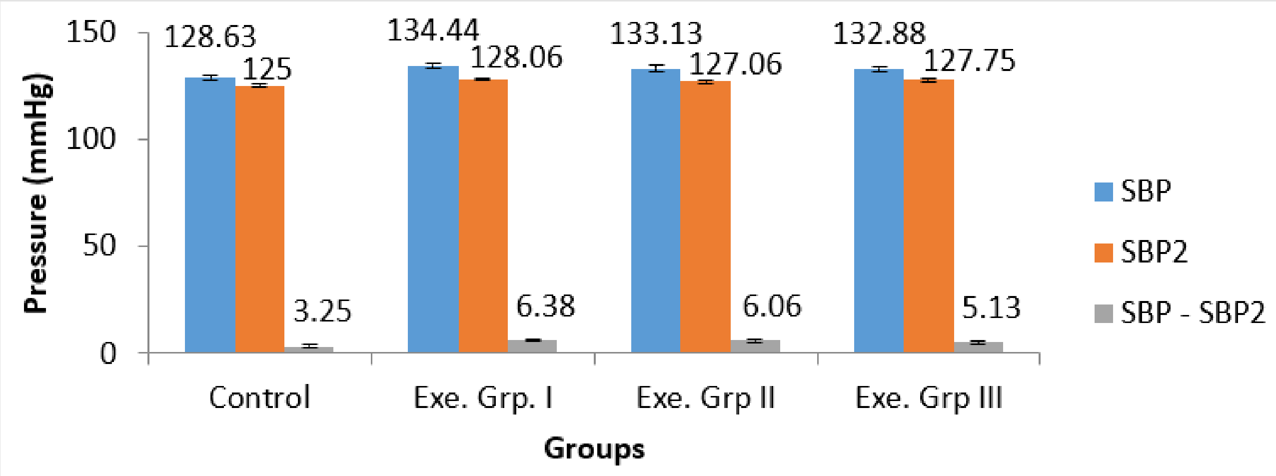

Figure 2: Changes in Systolic Blood Pressure at 24 Days across Groups.

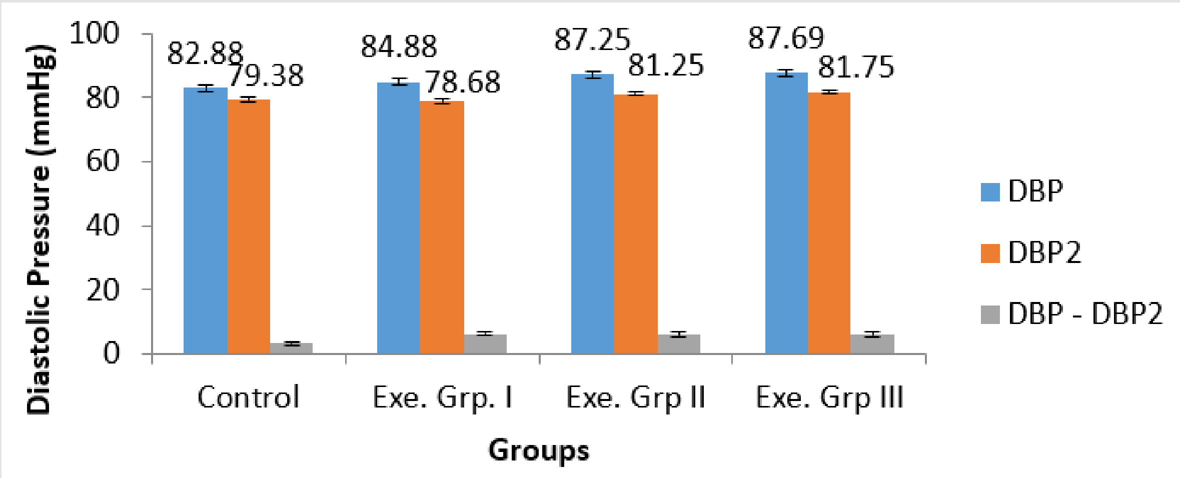

Figure 3: Changes in Diastolic Blood Pressure at 24 Days across Groups.

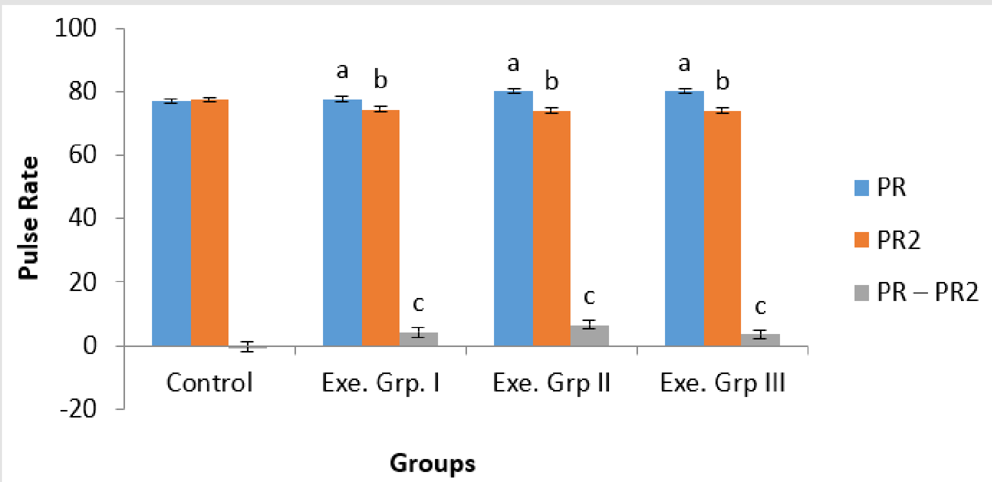

Figure 4: Changes in Pulse Rates at 24 Days across Groups.

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Sample Size

This study adopted the sample size formula by Charn and Biswas, (2013), which is widely used for clinical interventional studies. Sample size calculations will be based on previous studies (Bond et al. 2016 Millar, et al. [16] Kelley & Kelley 2010), that found isometric hand grip exercise to reduce BP by 5-10 mmHg. These authors reported standard deviation (SD) that ranged from 5-10 mmHg. Therefore, this study used a SD of 5 mmHg. We estimated the minimal clinically important difference (MCID) to be a change in BP of more than 5 mmHg, at 80% power, with a statistical significance level of 5% and a standard deviation of 5 points. Using these figures, a sample size of 16 participants for each of the four groups (1 for the control group and 3 for the exercise group) was estimated bringing the total to 64 participants. However, we increased the sample population to 64 for each group bringing the total participants recruited for this study to 256 in order to enhance the generalization of the study.

Plan of Analysis

The IBM SPSS 21.0 package program version 2010 was used in the data analysis. The data were statistically analyzed using the descriptive and inferential statistics. Data were analysed through an independent t-test, with statistical significance set at 5% to detect a MCID of 5 mmHg between the exercise and control groups. Descriptive statistics such as mean age, height, weight and BMI were used to describe patient's baseline characteristics.

Results

Four hundred participants were recruited and consented to be in the study, 265 of whom were eligible, provided adequate baseline data and were included in the study. Details of participants' characteristics and baseline measures investigated are presented under their respective subgroup (Tables 1-12).

Table 1: The Participants Social Demographic Data.

Characteristic	Control (n = 64)	Exercise (n = 192)
Mean (SD) Age (years)	42.06 (6.66)	42.06 (6.66)
Mean (SD) Height (m)	1.61 (0.09)	1.61 (0.09)
Mean (SD) Weight (Kg)	77.94 (10.80)	77.94 (10.80)
Mean (SD) BMI (Kg/m2)	30.20 (3.40)	30.20 (3.40)
Mean (SD) SP (mmHg)	128.6 (4.89)	133.47 (3.94)
Mean (SD) DP (mmHg)	83.00 (2.47)	86.60 (2.31)
Mean (SD) PR (b/min)	77.0 (6.76)	79.29 (4.42)

Note: Table 1 above is a descriptive demographic data of the participants. The baseline characteristics for both the control and exercises groups were similar with respect to age, height, weight, BMI, blood pressures – systolic and diastolic and pulse rate.

Table 2: Intervention Cardiovascular Indices of the Control group at 24 days.

Parameters	Day 0	Day 24.	Diff.	T-value	Df	Sig.
SBP (mmHg)	128.63±4.89	125.0±4.45	3.63±0.43	1.635	63	<0.001*
DBP (mmHg)	83.00±2.47	79.38±2.39	3.5±0.16	1.635	63	<0.001*
PR(b/min)	77.0±6.76	77.44±7.77	0.44±1.01	1.635	63	5.972

Note: Values are expressed as mean ± Standard Deviation (S.D), n=64. *P<0.05

Table 2 above shows the mean values of the BP and PRs of the control group at baseline and after 24 days. It shows a mean statistically significant reduction of 3.63 ± 0.90 mmHg and 3.5 ± 0.16 mmHg of the systolic and diastolic BP respectively and a mean increase of 0.44 ± 1.01b/min in the PR that was not statistically significant.

Table 3: Exercise Cardiovascular indices of the Exercise Group at the End of 24 Days.

Indices	Day 0 Exercise	After Day 24 Exercise	Diff.	T-value	Df	Sig.
SBP (mmHg)	133.47±3.94	127.62±4.18	5.85±4.16	1.635	191	<0.001*
DBP (mmHg)	86.60±2.31	80.56±2.95	6.04±1.36	1.635	191	<0.001*
PR (b/min)	79.29±4.42	74.08±4.27	5.21±1.01	1.635	191	<0.001*

Note: Values are expressed as mean ± Standard Deviation (S.D), n=192. *P<0.05

Table 3 above shows the exercise mean values of the BP and PRs of the exercise group at the end of 24 days. There was a mean statistically significant reduction of 5.85 ± 4.16 mmHg, 6.04 ± 1.36 mmHg and 5.21 ± 1.01b/min of the systolic and diastolic BP and PR respectively.

Table 4: The Mean Difference in the Blood Pressure and Pulse Rate between the Exercise and Control Group.

Indices	Exer. Group	Control Group	Diff.	T-value	Df	Sig.
SBP (mmHg)	5.85±4.16	3.63±0.43	2.22±1.36	2.84	255	0.004*
DBP (mmHg)	6.04±1.36	3.5±0.16	2.54±1.61	4.04	255	0.002*
PR (b/min)	5.21±1.01	-0.44±1.01	5.68±1.67	1.88	255	<0.001*

Note: Values are expressed as mean ± Standard Deviation (S.D), n=256. *P<0.05

Table 4 above shows the mean differences in the cardiovascular indices between the exercise and control groups. There was a statistically significant mean difference of 2.22 ± 1.22 mmHg, 2.54 ± 0.70 mmHg and 5.68 ± 1.63b/min of the systolic BP, diastolic BP and PR respectively in favour of the exercise group.

Table 5: Pre and Post Exercise Cardiovascular Indices of the Exercise Groups at the End of 48 days.

		SBP (mmHg)	DBP (mmHg)	PR (b/min.)
Exercise	Pre	134.43±3.96	84.87±2.82	77.56±4.61
Group 1	Post	130.06±3.66	81.62±4.60	75.62±5.88
	Diff.	4.37±3.72	3.25±4.18	1.94±5.56
Exercise	Pre	133.12±3.89	87.25±1.57	80.12±4.28
Group 2	Post	126.12±3.91	80.12±4.28	75.12±5.77
	Diff.	7.00±2.36	7.13±2.01	5.0±4.87
Exercise	Pre	132.87±4.04	87.68±1.19	80.18±4.10
Group 3	Post	122.43±4.76	77.93±1.94	78.25±3.35
	Diff.	10.43±4.28	9.75±1.91	1.93±4.32

Note: Values are expressed as mean ± Standard Deviation (S.D), n=192.

Table 5 above shows the pre and post exercise mean values of the cardiovascular systems indices across the three exercise groups at the end of 48 days. In group 1, there was a mean reduction of 4.37 ± 3.72 mmHg, 3.25 ± 4.18 mmHg and 1.94 ± 5.56b/min of the systolic blood pressure, diastolic BP and PR respectively. In group 2, there was a mean value of 7.00 ± 2.36 mmHg, 7.13 ± 2.01 mmHg and 5.00 ± 4.87b/min reduction in the systolic BP, diastolic BP and PR respectively. In group 3, there was a mean reduction of 10.44 ± 4.28 mmHg, 9.75 ± 1.91mmHg and 1.93 ± 4.32b/min in the systolic BP, diastolic BP and PR respectively.

Table 6: Test of Significance for the Mean Cardiovascular Difference between Baseline values and Post-Exercise Values at the End of 48 days.

Groups		Mean difference	Sig.(2-tailed)	Remark
Exercise Group 1	SBP(mmHg)	4.37±3.72	<0.001*	Significant
	DPB(mmHg)	3.25±4.18	<0.001*	Significant
	PR (b/min.)	1.93±5.56	.003*	Significant
Exercise Group 2	SBP(mmHg)	7.0±2.36	<0.001*	Significant
	DBP(mmHg)	6.93±2.01	<0.001*	Significant
	PR (b/min.)	5.0±4.87	<0.001*	Significant
Exercise Group 3	SBP(mmHg)	10.43±4.28	<0.001*	Significant
	DBP(mmHg)	9.75±1.91	<0.001*	Significant
	PR (b/min.)	1.93±4.32	0.004*	Significant

Note: Values are expressed as mean ± Standard Deviation (S.D), n=192. *P<0.05

Table 6 above shows an independence t-Test on the mean difference of the pre, and post exercise mean cardiovascular values across the three groups. There was a statistically significant difference in the values of the systolic BP, diastolic BP and PRs in all the three groups.

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Table 7: The Comparative Cardiovascular Effects of Cessation (Group 1) and Continuation (Group 2) of the Exercise Protocol at the End of 48 days.

Indices	Exercise Group I	Exercise Group 2	Diff.	T-value	Df	Sig.
SBP(mmHg)	4.37±3.72	7.0±2.36	2.63±1.10	2.381	127	<0.001*
DBP(mmHg)	3.25±4.18	6.93±2.01	3.68±1.16	3.174	127	<0.001*
PR(b/min)	1.93±5.56	5.0±4.87	3.07±1.85	1.656	127	<0.001*

Note: Values are expressed as mean ± Standard Deviation (S.D), n=128. *P<0.05

Table 7 above shows the comparative cardiovascular effects of cessation (Exercise Group 1) and continuation (Exercise Group 2) of the exercise protocol at the End of 48 days. There was a statistically significant further reduction with a mean value of 2.63 ± 1.10 mmHg, 3.68 ± 1.16mmHg and 3.07 ± 1.85b/min in the systolic and diastolic BPs and PR respectively following a continuation of the exercise protocol. This means that continuation of the of the exercise protocol after 24 days as seen in group 2 produced a significant reduction when compared to cessation of the exercise protocols.

Table 8: The Comparative Cardiovascular Effects of Continuation and Increase in Intensity of the Exercise Protocol at the End of 48 days.

Indices	Exercise Group 2	Exercise Group 3	Diff.	T-value	Df	Sig.
SBP(mmHg)	7.0±2.36	10.43±4.28	3.43±1.22	2.381	127	<0.001*
DBP(mmHg)	6.93±2.01	9.75±1.91	2.82±0.70	3.174	127	0.003*
PR(b/min)	5.0±4.87	1.93±4.32	3.07±1.63	1.656	127	<0.001*

Note: Values are expressed as mean ± Standard Deviation (S.D), n=128. *P<0.05

Table 8 above shows the comparative cardiovascular effects of continuation (Exercise Group 2) and increase in exercise intensity (Exercise Group 3) of the exercise protocol at the end of 48 days. There was greater reduction with a mean value of 3.43 ± 1.22 mmHg and 2.82 ± 0.70 mmHg in the systolic and diastolic BPs and an increase of 3.07 ± 1.63b/min in PR respectively, following an increase in the intensity of the exercise protocol. These values demonstrated a statistically significant difference in the means between the two groups in favour of group 3. This showed that increase in intensity of the exercise protocol after 24 days produced a significant reduction in the values of the cardiovascular variables when compared with continuation of the exercise protocol at the end of 24 days. However, it also resulted in a significant increase in PR.

Table 9: The mean difference between the post-exercise values at the End of 24 days and at 48 days of the cardiovascular indices of the Exercise group 1.

Indices	Post-Exercise at 24 days	Post-Exercise at 48 days	Diff.	T-value	Df	Sig.
SBP(mmHg)	128.06±4.41	130.06±3.66	2.0±0.04	2.381	63	0 .009*
DBP(mmHg)	78.68±4.02	81.62±4.60	2.9±0.02	3.174	63	0.006*
PR(b/min)	74.37±4.61	75.62±5.88	1.25±0.14	1.656	63	0.008*

Note: Values are expressed as mean ± Standard Deviation (S.D), n=64. *P<0.05

Table 9 above shows the comparative changes in the mean values of the cardiovascular indices of group 1 at the end of 24 and 48 days. A statistically significant mean difference in the systolic BP, diastolic BP and PR of 2.0 ± 0.04 mmHg, 2.94 ± 0.02 mmHg and 1.25 ± 0.14b/min respectively was observed. The values were statistically significant showing that from the 24 days' post cessation of the exercise protocol, there was a statistically significant rise in the values of the cardiovascular indices.

Table 10: The Mean Difference between the Post-exercise Values at the End of 24 days and at 48 days of the Cardiovascular Indices of the Exercise Group 2.

Indices	Exercise after 24 days	Exercise after 48 days	Diff.	T-value	Df	Sig.
SBP (mmHg)	127.06±3.37	126.12±3.91	-0.94±0.03	2.381	63	0.072
DBP (mmHg)	81.25±1.61	80.12±4.28	-1.13±0.01	3.174	63	0.061
PR(b/min)	76.31±4.23	75.12±5.77	-1.19±0.24	1.656	63	0.007

Note: Values are expressed as mean ± Standard Deviation (S.D), n=64. *P<0.05

Table 10 shows the comparative changes in the mean values of the cardiovascular indices of group 2 at the end of 24 days and 48days. There was no significant mean difference of 0.94 ± 0.03mmHg, 1.13 ± 0.01 mmHg and 1.19 ± 0.24b/min in the systolic BP, diastolic BP and PR respectively, except for PR.

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Table 11: The mean difference between the Post-exercise Values at the End of 24 days and at 48 days of the Cardiovascular Indices of the Exercise group 3.

Indices	Exercise after 24 days	Exercise after 48 days	Diff.	T-value	Df	Sig.
SBP (mmHg)	127.75±4.83	122.43±4.76	-5.31±1.10	2.381	63	<0.001*
DBP mmHg)	81.75±4.10	77.93±1.94	-3.82±1.16	3.174	63	<0.001*
PR (b/min)	73.93±4.23	78.25±3.35	-4.32±1.84	1.656	63	<0.001*

Note: Values are expressed as mean ± Standard Deviation (S.D), n=64. *P<0.05

Table 11 shows the comparative changes in the mean values of the cardiovascular indices of group 3 at the end of 24 and 48 days. There was statistically significant mean difference of 5.31 ± 1.10 mmHg, 3.82 ± 1.16 mmHg and -4.32 ± 1.84b/min in the systolic BP, diastolic BP and PR respectively. This implies that continuation of the exercise protocol at 50% MVC produced further significant reductions in the values of the systolic and diastolic BPs, however there was a significant rise in PR.

Table 12: Comparative Analysis of the Three Exercise Groups of the Cardiovascular Indices at the End of 48 days.

		Sum of Squares	Df	Mean Square	F	Sig.
SBP (mmHg)	Between Groups	242.042	2	121.021	11.491	<0.001
	Within Groups	473.938	189	10.532		
	Total	715.979	191			
DBP (mmHg)	Between Groups	231.292	2	115.646	21.532	<0.001
	Within Groups	241.688	189	5.371		
	Total	472.979	191			
PR (b/min.)	Between Groups	38.375	2	19.188	1.950	<0.001
	Within Groups	442.875	189	9.842		
	Total	481.250	191			

Note: Values are expressed as mean ± Standard Deviation (S.D), n=192. *P<0.05

Table 12 is a one-way analysis of variance comparing the means of the three exercise groups. There was a significant difference in the means of all the variables analyzed. This implies that the three different exercise protocols produced a statistically significant effects on the cardiovascular system.

Discussion

This study set out to investigate the effects of variation of the duration and intensity of the isometric handgrip exercise protocol on the BP and PR responses in individuals with prehypertension. This study has demonstrated that there is strong evidence supporting the effectiveness of variation of the duration and intensity of isometric hand grip exercise on the BP and PR of hypertensive individuals in favour of the exercise group. However, the control group also had a significant reduction in BP in the control group, but of lesser magnitude.

Strength of the Study

Previous studies on effect of isometric handgrip exercise on hypertensive individuals have methodological issues such as major design flaws and small sample size. However, this study adopted a pragmatic randomised controlled design with a much larger sample size. According to (Millar, et al. [16]) there is scarcity of research evidence on the effects of extended training and training cessation [16]. However, one of the strengths of this study is that is investigated the effect of cessation, continuation and increase in exercise intensity of the isometric effort in both groups. Our study demonstrated that the cessation of the exercise protocol in group 1, resulted in a reversal of systolic BP, diastolic BP and PR towards the pre-exercise values, however, but did not return to baseline levels at 24 days' post cessation. In group 2, continuation of the exercise protocol for another 24 days further resulted in a slight reduction to these variables. In group 3, at the end of 48 days. continuation of the exercise protocol at 50% MVC further produced further a significant reduction in the systolic and diastolic BPs, however, PR increased. These findings are similar to previous studies that investigated the effects of moderation of exercise therapy on resting BP of individuals with hypertension. Millar [17] reported a return to baseline values of cardiovascular parameters such as BP following approximately six weeks after cessation of training [17].

Meredith, et al. [18] reported a decrease in resting BP following a four weeks of exercise bicycle ergometer [18]. Murray, et al. [19], examined the effects of aerobic exercise training in 17 prehypertensive young men using cycle ergometer at 30 minutes and four sessions a week [19]. At the end of four sessions, the systolic and diastolic BP were lowered by 10 ± 1 mmHg and 8 ± 7 mmHg respectively with no further decrease after the second week. Following cessation of exercise, while the resting systolic BP returned to pretraining values within one week, the diastole BP remained lower. At the end of the second week, the systolic and diastole BPs increased by 5 mmHg and 3 mmHg respectively above pretraining values. Similarly, Erin [20], reported that the effects of exercise cessation for two weeks reduced BP benefits gained from a high intensity interval training of two weeks [20]. These findings are consistent with this study found, that there were no significant reductions in BP levels after 24 consecutive days of continuation of the exercise protocol at the same intensity. However, increasing the force of contraction further was what caused a significant reduction in the resting systolic and diastolic BPs.

Comparison with Other Studies

The study findings have shown that isometric exercise in combination with lifestyle changes provided significant reduction in the systolic BP, diastolic BP and PR with a mean value of 5.85 ± 4.16 mmHg, 6.04 ± 1.36 mmHg and 5.21 ± 1.01 respectively at the end of 24 consecutive days at 30% MVC compared with the control. These results are clinically significant because previous authors have shown that a 5 mmHg decrease in BP can reduce the risk of stroke occurrence by 40% and decrease the risk of heart disease by 15-20% (Jones, et al. 2008) [21]. The result is consistent with a systematic review which demonstrated that isometric training decreases office BP by up to 7 mmHg for systolic and 5 mmHg for diastolic in patients with hypertension [22]. Millar, et al. [16] reported that the average magnitude of systolic and diastolic BP decreases during isometric exercise ranged between 3-8 mmHg and 2-6 mmHg respectively [16]. However, Peters, et al. [23], reported that six weeks of isometric exercise training was effective in lowering systolic BP but not diastolic BP in pre-hypertensive and hypertensive individuals [23]. In contrast, Ray and Carasco [24], found that isometric exercise led to a reduction in diastolic arterial pressure but not systolic arterial pressure [24]. Despite this contrasting findings, several studies have shown a reduction in both the systolic and diastolic BP using isometric exercises in patients with prehypertension and hypertension [5,12,13,16,22]. However, the results of these studies should be interpreted with caution because they are generalized due to their small sample size and some of them lacked a control group.

This study compares favourably with Wiley, et al. [5.24]. In the Wiley, et al. [5] study, participants were trained with four, 2 minutes' isometric handgrip contractions with 3 minutes' rests period between contractions at 30% MVC5. The isometric exercise training was performed three times per week for 8 weeks. Although the authors reported a significant reduction in both systolic and diastolic resting BPs, with a mean value of 12.5 and 14.9 mmHg, respectively, the study had a small sample size (n = 8). The study conducted by Ray and Carrasco [24], found a 3 mmHg and 5 mmHg reduction in systolic and diastolic pressure respectively in favour of isometric handgrip exercise [24]. The participants performed isometric hand grip exercised for five weeks at 30% MVC, 4 times per week, with each contraction separated by five-minute rest periods. A major difference between these studies and this current study is that we involved a larger number of participants and increased the frequency of exercise training. The control group recorded a mean reduction of 3.63 ± 0.90 and 3.5 ± 0.16 of the systolic and diastolic BP respectively. However, there a non-statistically significant increase of 0.44 ± 1.01 in the PR. This is consistent with a previous meta-analysis that suggested that lifestyle modification can lead to a reduction in systolic and diastolic BPs by about 3 mmHg [25].

The amount of BP reduction noted in the control group is also clinically significant using figures from the Ray and Carasco [24], study which reported that a 2 mmHg drop in diastolic BP would lead to a 17% decrease in hypertension, 6% reduction in coronary heart disease and 15% reduction in stroke-related events [24]. Although several authors have investigated the benefit of lifestyle changes on individuals with hypertension, they have mainly focused on the effect of a single lifestyle modification and not a holistic approach such as weight and salt intake reduction [26]. However, there is no strong evidence to suggest that the use of holistic approach will produce additional antihypertensive effect. The seventh report of the JNC7 (2003) [2], stated that Lifestyle modification is indicated for all patients with hypertension, regardless of drug therapy, because it may reduce, or even eliminate, the need for antihypertensive drugs. Lifestyle modification has also been recommended as the first line of treatment for hypertensive patients (Sever and Messerli [26]). In a study by He, et al. [27], weight loss of as little as 4.5 kg reduces BP and/or prevents hypertension in a large proportion of overweight persons [27]. Dietary Approaches to Stop Hypertension (DASH) eating plan which is a diet rich in fruits, vegetables, and low-fat dairy products with a reduced content of dietary cholesterol, saturated and total fat have been showed to reduce BP [28]. It is rich in potassium and calcium content. A long term (more than 4 weeks) low sodium diet in Caucasians is effective in reducing blood pressure, both in people with hypertension and in people with normal blood pressure [27]. It was further reported that physical activity and dietary intervention remains the most effective and physiologically desirable approaches [29,30]. The current challenge, however, is developing and implementing effective clinical and public health strategies that will lead to sustained lifestyle modification.

Implications for Practice and Research

Isometric handgrip exercise at 30% MVC, in combination with lifestyle modification, should be recommended to patients with prehypertension and should form part of a comprehensive prehypertension strategies to prevent BP from rising to hypertension range. It must be emphasized however that regular monitoring of the BP is necessary to ascertain the need for cessation, continuation or increase in intensity of the exercise protocol. Future research into the chronic post isometric handgrip exercise responses with durations of over six months should be considered to determine the optimal mode, duration, and frequency of handgrip exercise needed to achieve significant beneficial effects on arterial BP. Future studies methodologies or protocols should be systematic with clear empirical, measurable, and comparable data that will ensure their results are readily repeatable.

Conclusion

This study has demonstrated that isometric handgrip exercise could be an effective strategy in the attenuation of BP in individuals with prehypertension especially when combined with the routinely recommended lifestyle modifications. It has also established that increase in the intensity of the exercise protocols produced more beneficial results compared with increase in exercise duration.

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Contributors

OUG conceived the study. All authors contributed to the design of the study. OUG directed the study and managed data acquisition. OUG had full access to all of the data in the study and NE, EC, UFC, EE and NOZ took responsibility for data collection. CO, OUG, EC and EK provided additional important intellectual and substantial scientific input on all drafts of the study. CO managed all redrafts of the manuscript. CO undertook provided advice on the statistical analyses. OUG is guarantor for the study.

Ethical Approval

Ethical approval was from the Federal Medical Centre Asaba Delta State (FMC/ASB/A81.VOLXII/101) and Faculty of Basic Medical Sciences, Delta State University, Abraka, Delta State, Nigeria (REC/FBMS/DELSU/18/16/103).

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Conflict of Interests

The authors have declared that no competing interests exist.

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