Effects of Interval Training Programme on Resting Heart Rate in Subjects with Hypertension: A Randomized Controlled Trial

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[1]Sikiru Lamina, [2]Goddy Okoye, [2]Charles Ezema, [3]Anthonia Ezugwu and [4]Theresa Anele

[1]Department of Biomedical Technology, School of Health Technology, Federal University of Technology, Owerri, [2]Department Medical Rehabilitation Faculty of Health Sciences and Technology, University of Nigeria, Enugu Campus, Enugu, Nigeria, Department of [3]Physiotherapy, University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu, Nigeria and Department of [4]Radiology, Federal Medical Center, Owerri, Nigeria

ABSTRACT

Background: Heart rate (HR) is a determinant of cardiovascular event risk in patient with hypertension. The primary purpose of the present study was to investigate the effect of interval training program on HR in black African subjects with hypertension.

Methods: Two hundred and forty five male patients with mild to moderate (Systolic Blood Pressure [SBP] between 140-179 & Diastolic Blood Pressure [DBP] between 90-109 mmHg) essential hypertension were age-matched and grouped into interval and control groups. The interval (work: rest ratio of 1:1) groups involved in an 8-weeks interval training programs of between 45-60 minutes, at intensities of 60-79% of HR max, while the control group remained sedentary during this period. Blood pressure (SBP and DBP), VO_2max and HR were assessed. Student's t and Pearson correlation tests were used in data analysis.

Results: Findings of the study revealed significant effect of exercise training program on HR. Also, changes in VO_2max negatively correlated with changes in HR (r= -.503) at $p<0.05$.

Conclusion: It was concluded that moderate intensity interval training programs is effective in the non-pharmacological adjunct management of hypertension and may prevent cardiovascular event through the down regulation of HR in hypertension.

Key words: Hypertension; Interval exercise;

INTRODUCTION

Hypertension is a highly prevalent disease and a common risk factor for different cardiovascular diseases, with a major impact on morbidity and mortality [1]. Previous studies have shown a positive association between resting heart rate (RHR) and both all-cause and cardiovascular mortality [2]. Furthermore, RHR may be an independent risk factor for cardiovascular deaths in hypertensive subjects [3, 4].

Hypertensive individuals present with a series of functional and anatomic deficits, such as increased vascular resistance, vessel rarefaction, increased heart energy expenditure, increased stroke work, impaired baroreceptor reflex control, hormonal imbalance with overactivation of the renin-angiotensin system, and increased insulin resistance [5]. Most of these effects contribute to increased sympathetic activity and depressed cardiovascular control [1].

Few studies have examined the relationship between RHR and hypertension management, particularly in the non pharmacology and non invasive techniques. In addition, while most of the previous studies investigating the effects of exercise on hypertension and its associated factors have been conducted in Caucasian and other mixed black subjects; it is known that genetic, environmental factors and gene-environmental interaction have been implicated in the cause of hypertension, [6-8, 10-13]

This interpersonal and interracial differences in subjects clearly indicate the need for a study on pure older black African population. Therefore, the purpose of the present study was to

investigate the effect of interval training programme on RHR in subjects with hypertension.

METHODS

Research design: An age-matched randomized double blind independent groups design was used to determine the influence of the interval and continuous training program on cardiovascular parameters. Subjects' ages were arranged in ascending order (50 to 70 years) and then assigned to interval, continuous and control groups in an alternating pattern (age-matched). One week wash out period was established and pretest was administered to all subjects on the last day of the wash out period. Following wash out and pretest, all subjects were placed on methyldopa (500mg-1g daily in divided doses of 2 to 4 times) based on the subjects responses and tolerance to therapy.

The interval and continuous groups were involved in interval and continuous training programs for 8 weeks, while the control group remained sedentary during the period. At the end of the training and sedentary period, another one week wash out period was established and posttest was administered to all subjects on the last day of the wash out period.

Subjects: Population for the study was male essential hypertensive subjects attending the hypertensive clinic of Murtala Muhammed Specialist Hospital Kano Nigeria. Subjects were fully informed about the experimental procedures, risk and protocol, after which they gave their informed consent in accordance with the American College of Sports Medicine (ACSM) guidelines, regarding the use of human subjects [14] as recommended by the human subject protocol. Ethical approval was granted by the Ethical Committee of Kano State Hospitals Management Board and the faculty of Health Sciences, College of Medicine, University of Nigeria, Enugu Campus.

Inclusion criteria: Only those who volunteered to participate in the study were recruited. Subjects between the age range of 50-70 years with chronic mild to moderate and stable (>1 year duration) hypertension (SBP between 140-179 & DBP between 90-109 mmHg) were selected. Subjects who had stopped taking antihypertensive drugs or on a single antihypertensive medication were also recruited. All subjects were sedentary and have no history of psychiatry or psychological disorders or abnormalities.

Exclusion criteria: Obese or underweight (BMI between 20 & 30 kg/m^2), smokers, alcoholic, diabetic, other cardiac, renal, respiratory disease patients were excluded. Those involved in vigorous physical activities and above averagely physically fit (VO_2max >27 & >33 ml/kg.min for over 60 & 50 years old respectively) were also excluded.

A total of 323 chronic and stable, males with mild to moderate essential hypertension satisfied the necessary study criteria. Subjects were age-matched and randomly grouped into interval (162) and control (161) groups. They were fully informed about the experimental procedures, risk and protocol, after which they gave their informed consent in accordance with the ACSM guidelines, regarding the use of human subjects [14] as recommended by the human subject protocol. The Ethical Committee of Kano State Hospitals Management Board granted ethical approval.

PRETEST PROCEDURE

Wash out Period: All subjects on anti-hypertensive drugs were asked to stop all forms of medication and in replacement, were given placebo tablets (consisted of mainly lactose and inert substance) in a single blind method. [15, 16] All subjects including those not on any anti hypertensive medications were placed on placebo tablets for one week (7 days); this is known as "Wash out period". The purpose of the wash out period was to get rid of the effects of previously taken anti hypertensive drugs/medications. During the wash out period all subjects were instructed to avoid any strenuous physical activities and report to the hypertensive clinic for daily blood pressure monitoring and general observation. The pretest procedure was conducted at the last day of the wash out period, in the Department of Physiotherapy of Murtala Mohammed Specialist Hospital (MMSH), Kano between 8:00 am and 10:00 am.

Physiological measurement: Subjects resting BP (SBP and DBP) and Heart Rate (HR) were monitored from the right arm as described by Walker et al [16] using an automated digital electronic BP monitor (Omron digital BP monitor, Model 11 EM 403c; Tokyo Japan). The equipment was used to take the BP and HR at rest, during exercise and after exercise test. This procedure was repeated and the averages of the two readings were recorded. These measurements were monitored between 8:00 am and 10:00am each test day.

Stress test: The Young Men Christian Association (YMCA) sub-maximal cycle ergometry test protocol was used to assess subject's aerobic power as described by ACSM [17], Golding, Meyers and Sinniny. [18] The bicycle seat height was adjusted and the subjects' knee slightly flexed when the pedal was in the down position. Exercise test started with a 2 to 3 minutes warm up at zero resistance in order to acquaint the subjects with the cycle ergometer. According to Brook, Fahey and White [19]; Pollock and Wilmore [20] middle aged, less fit, cardiac patient generally begins at 100 or 150 to 300 $kgm.min^{-1}$ (17w or 25w to 50w respectively) with power increments of 5-25 watts per stage. At the end of the test, a 2 to 3 minutes recovery period (cool down) at zero resistance pedaling was administered.

Test procedure: The test procedure was conducted in the Department of Physiotherapy of Murtala Mohammed Specialist Hospital (MMSH), Kano between 8:00 am and 10:00 am.

Training program: Following stress test and prior to the exercise training, all subjects in the control, interval and control groups were re-assessed by the physician and were prescribed with aldomet (methyldopa) as necessary. During the training and sedentary period (8 weeks) all subjects in the interval, continuous and control groups were placed on methyldopa according to their pre-recruitment doses and responses at 500mg to 1g daily in divided doses.

Methyldopa was preferred because it does not alter normal hemodynamic responses to exercise. [21] It is a well-tolerated and widely prescribed antihypertensive drug in the Northern Nigeria [22], where the study was conducted. Methyldopa is also useful in the treatment of mild to moderately severe hypertension. [23] Subjects maintained these prescriptions with regular medical consultation throughout the period of this study.

The interval group (group 1): After a 10-minutes warm up (pedaling at zero resistance), subjects in the interval group exercised on a bicycle ergometer at a moderate intensity of between 60-79% of their HR max reserve [24, 25] that was estimated as stated below, from 220 minus the age of a subject as recommended by ACSM [24]. The starting workload was 100 kgm (17 watts) which was increased at a pedal speed of 50rpm to obtain 60% of their HR max was increased in the first two weeks to and level up at 79% of their HR max and this value was maintained throughout the remaining part of the training period at a work: rest duration of 1:1 of 6 minutes each [24]. During the 6-minutes rest interval period, subjects pedal at zero intensity. The initial of exercise session was increased from 45 minutes in the first two weeks of training to and leveled up at 60 minutes throughout the remaining part of the training. Following the exercise, another 10- minutes cool down was established by pedaling at zero resistance. Exercise session of three times per week was maintained throughout the 8 weeks period of training.

The control group (group 3): Subjects in the control group were instructed not to undertake any organized/structured physical activity apart from the activity of daily living during the 8 weeks period of study.

Posttest procedure

Wash Out Period: At the end of the 8 weeks training and sedentary period, all subjects remained sedentary (no exercise) and were asked to stop methyldopa. Subjects were instead prescribed with placebo tablets in a single blinded method for one week in order to get rid the effect of the methyldopa taken during the training period.

Post training physiological (SBP and DBP) assessment and stress test were conducted as earlier described in the pretest procedures using standardized protocols, techniques and methods by the same investigators.

All pre and post test measurements were recorded on a data sheet. Two hundred and forty five subjects (140 from interval and 105 from control groups) completed the eight weeks training program. Seventy eight subjects (22 from interval and 56 from control groups) had dropped out because of non-compliance, unfavorable responses to methyldopa and exercise training or had incomplete data; therefore, the data of 245 subjects were used in the statistical analysis (figure 1).

Statistical analysis: Following data collection, the measured and derived variables were statistically analyzed. The descriptive statistics (Means & standard deviations) of the subjects physical characteristics, estimated VO_2max and other cardiovascular parameters were determined. Independent t test was conducted to assess the treatment outcome. Pearson product moment correlation test was also computed for the variables (changes in RPP, BP & changes in VO_2max) of interest. In the t-test and correlation tests, the difference between subjects post-training and pre-training measurements (changed score) were used as dependent measures. All statistical analysis was performed on a Toshiba compatible microcomputer using the statistical package for the social science (SPSS), windows Version 16.0 Chicago IL, USA. The probability level for all the above tests was set at 0.05 to indicate significance.

RESULTS

Interval and control groups' physical characteristics (mean± SD): The subject's age ranged between 50 and 70years. The mean± SD age for the interval and control groups was 58.40±6.91years and 58.27 ±6.24years respectively. The interval group mean± SD for height, weight and BMI was 167.78±7.81cm, 70.18±11.37kg, and 24.96±3.88 $kg.m^{-2}$ respectively. The control group mean± SD for height, weight and BMI was 167.89±5.31cm, 68.47±17.07 kg, 24.16±4.91 $kg.m^{-2}$ respectively.

Interval group pre versus post treatment variables mean± SD (table 1): The interval group pretreatment versus (Vs), post treatment mean± SD values for SBP (mmHg) was 166.05± 14.10 (Vs) 150.35±16.67 The interval group pretreatment versus (Vs), post treatment mean± SD values for DBP (mmHg) was 96.80 ±3.38 (Vs) 94.08±5.31. The interval group pretreatment versus (Vs), post treatment mean± SD values for HR (beats/min) was 83.25±11.69 (Vs) 75.50±7.80.The interval group pretreatment versus (Vs), post treatment mean± SD values for VO_2max $ml.kg^{-1}.min^{-1}$ was 23.67±9.15 (Vs) 37.46±7.42

Control group pre and post treatment variable mean± SD (table 1): The control group pretreatment versus (Vs), post treatment mean± SD values for SBP (mmHg) was 160.87±13.23 (Vs) 163.47 ±14.88 The control group pretreatment versus (Vs), post treatment mean± SD values for DBP (mmHg) was 97.17±1.43 (Vs) 96.10 ±2.67 The control group pretreatment versus (Vs), post treatment mean± SD values for HR (beats/min) was 82.60±22.62 (Vs) 80.50±21.99. The control group pretreatment versus (Vs), post treatment mean± SD values for VO_2max ($ml.kg^{-1}.min^{-1}$) was 21.23±5.76 (Vs) 22.82±7.44.

Students' t test and correlation test results

Table 2 students't test results indicated a significant reduction in the exercise groups over control in SBP ($t=13.148$, $p=0.000$), DBP ($t= -6.560$, $p=0.000$), HR ($t = -4.650$, $p= 0.000$) and VO_2 max ($t= 11.959$, $p=0.000$) at $p<0.05$.

Results (figure 2) showed significant correlation between baseline values and other variables such as: DBP (.242); DBP (-.128) and VO_2max (-.304). Results also showed significant negative correlation between exercise changes in HR and changes in VO_2 max ($r= -.503$) at $p< 0.05$(figure 3).

DISCUSSION

The findings of the present study indicated a

significant reduction in SBP, DBP, HR, and significant increase in VO_2max as a result of interval exercise training; several previous studies[26, 27, 28] have reported similar findings. The present study also demonstrated a significant reduction in exercise group HR over control. Our study also revealed a significant correlation between exercise changes in HR and Vo_2max.

A similar study with similar result was conducted in 2009 by Cornelissen and co-workers [29], they investigated the effects of endurance training intensity on systolic blood pressure (SBP) and heart rate (HR) at rest (before exercise), and during and after a maximal exercise test; and (2) on measures of HR variability at rest before exercise and during recovery from the exercise test. A randomized crossover study comprising three 10-week periods of study was performed. In the first and third period, participants exercised at lower or higher intensity (33% or 66% of HR reserve) in random order, with a sedentary period in between. Their results showed that in the three conditions (at rest before exercise, during exercise and during recovery) endurance training at lower and higher intensity to reduce SBP significantly ($P<0.05$). The effect of training on HR at rest, during exercise and recovery was more pronounced ($P<0.05$) with higher intensity. In conclusion, both training programmes exert similar effects on SBP at rest, during exercise and during post-exercise recovery, whereas the effects on HR are more pronounced after higher intensity training.

Another related study, though, an animal experiment was conducted by **Véras-Silva et al** [30] The effects of exercise training of low and high intensity on resting blood pressure were studied in sedentary (n = 17), low- (n = 17), and high-intensity exercise-trained (n = 17) consequences in spontaneously hypertensive rats (SHR). Exercise training was performed on a treadmill for 60 min, 5 times per week for 18 weeks, at 55% or 85% maximum oxygen uptake. They reported that low-intensity exercise-trained rats had a significantly lower mean blood pressure than sedentary and high-intensity exercise-trained rats (160 ± 4 vs. 175 ± 3 and 173 ± 2 mmHg, respectively). Cardiac index (20 ± 1 vs. 24 ± 1 and 24 ± 1 ml · min^{1} · 100 g^{1}, respectively) and heart rate (332 ± 6 vs. 372 ± 14 and 345 ± 9 beats/min, respectively) were significantly lower in low-intensity exercise-trained rats than in sedentary and high-intensity exercise-trained rats. They concluded that low-intensity, but not high-intensity, exercise training decreases heart rate and cardiac output and, consequently, attenuates hypertension in SHR.

Table 1: Groups pre and posttest mean(X) ± standard deviation (SD) (N = 245)

Variables	Interval group X±SD (n=140)		Control group X±SD (n= 105)	
	Pretest	Posttest	Pretest	Posttest
SBP(mmHg)	166.05±14.10	150.35±16.67	160.87±23.91	163.47±14.88
DBP(mmHg)	96.80±3.38	94.08±5.31	97.17±7.20	96.10±2.67
VO_2max(ml/kg/min)	23.67±9.15	37.46±7.42	21.23±5.76	22.82±7.44
HR(beats/min)	83.25±11.69	75.50±7.80	82.60±22.62	80.50±21.99

Table 2: Groups changed scores mean(X) ± standard deviation (SD) and t-test values (N = 245)

Variables	Changed score values X±SD Interval group n= 140	Control group n= 105	t-values	p-values
SBP(mmHg)	-15.70±13.16	2.61± 7.85	-13.148	0.000*
DBP(mmHg)	-4.01±4.34	-1.07±1.76	-6.560	0.000*
VO_2max(ml/kg/min)	13.79±9.99	1.59± 3.52	11.959	0.000*
HR(beats/min)	-7.75±9.34	-2.11±9.46	-4.650	0.000*

* Significant, p< 0.05

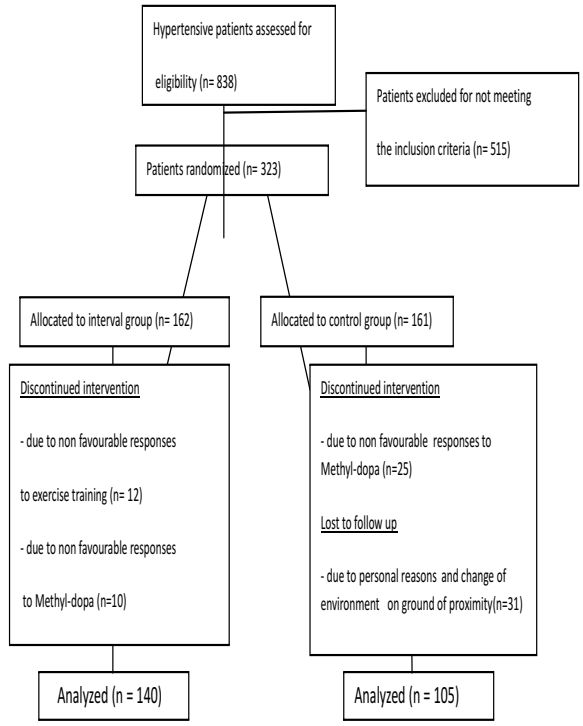


Fig 1: Study design flow chat

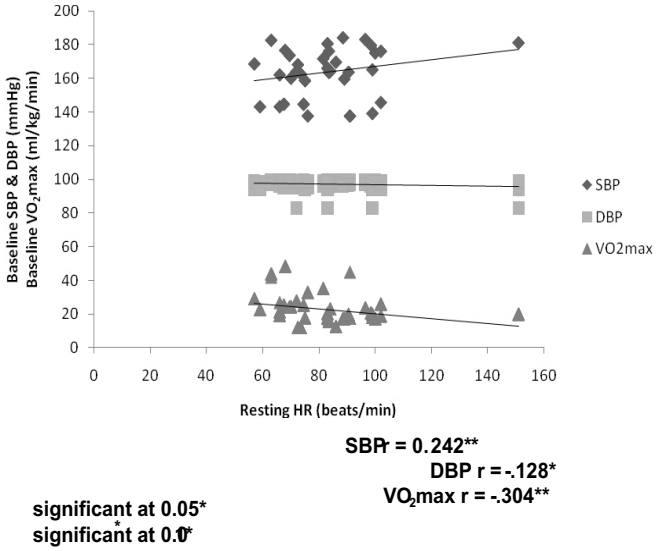
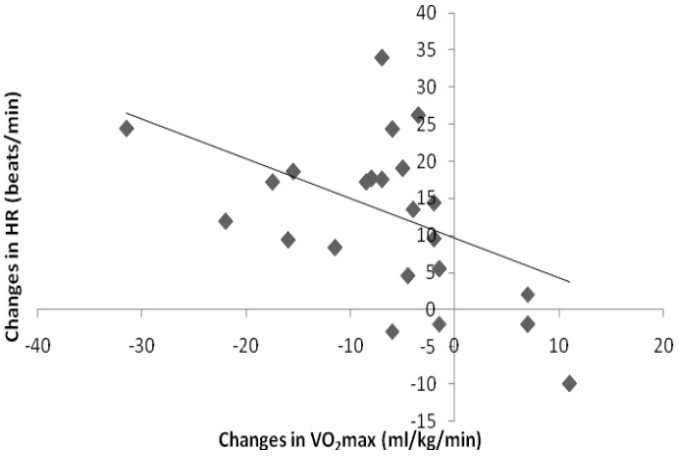


Fig 2: Correlation between baseline HR and other variables baseline values (N=245).



r = -0.503* significant at 0.05*
Fig 3: correlation between training changes in Vo_2max and HR (N=140).

Laterza et al [26] hypothesized that exercise training would improve baroreflex control of muscle sympathetic nerve activity (MSNA) and heart rate (HR) in patients with hypertension and that exercise training would reduce MSNA and blood pressure (BP) in hypertensive patients. Twenty never-treated hypertensive patients were randomly assigned into 2 groups: exercise-trained (n=11; age: 46±2 years) and untrained (n=9; age: 42±2 years) patients. An age-matched normotensive exercise-trained group (n=12; age: 42±2 years) was also studied. Baroreflex control of MSNA (microneurography) and HR (ECG) was assessed by stepwise intravenous infusions of phenylephrine and sodium nitroprusside and analyzed by linear regression. BP was monitored on a beat-to-beat basis. Exercise training consisted of three 60-minute exercise sessions per week for 4 months. They reported that; in hypertensive patients, exercise training significantly reduced BP ($P<0.01$) and MSNA ($P<0.01$) levels and significantly increased baroreflex control of MSNA and HR during increases ($P<0.01$ and $P<0.03$, respectively) and decreases ($P<0.01$ and $P<0.03$, respectively) in BP. The baseline (preintervention) difference in baroreflex sensitivity between hypertensive patients and normotensive individuals was no longer observed after exercise training. No significant changes were found in untrained hypertensive patients. In conclusion, exercise training restores the baroreflex control of MSNA and HR in hypertensive patients.

There seems to be conscientious agreement that exercise has beneficial effect on HR. However, the present study differs from others in the type of exercise and exercise parameters or the population investigated and subjects condition.

CONCLUSION

Our study demonstrated a rationale basis for the adjunct role of long term moderate intensity interval exercise training in the down regulation of blood pressure and cardiovascular event risk factor (HR) modification. Therefore, exercise specialists and other therapists should feel confident in the use of this form of therapy in the non-pharmacological adjunct management of hypertension.

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