Therapeutic effect of a moderate intensity interval training program on the lipid profile in men with hypertension: A randomized controlled trial

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Abstract

Objective: Physical inactivity has been established as a major primary risk factor for the development of hypertension. Also, factors such as elevated total cholesterol (TC) and reduced high density lipoprotein cholesterol (HDL) have been implicated as risk factors for coronary events in hypertension. The purpose of the present study was to investigate the effect of interval training program on blood pressure and lipid profile of subjects with hypertension.
Materials and Methods: A total of 245 male patients with mild-to-moderate hypertension (systolic blood pressure [SBP] between 140 and 180 mmHg and diastolic blood pressure [DBP] between 90 and 109 mmHg) were age matched and grouped into interval and control groups. The interval (n=140; 58.90 ± 7.35 years) group was involved in an 8-week interval training (60–79% HR max reserve) program of between 45 minutes and 60 minutes at a work/rest ratio of 1:1 of 6 minutes each, while the control hypertensive (n=105; 58.27 ± 6.24 years) group remained sedentary during this period. Cardiovascular parameters (SBP and DBP), VO_2 max, TC, HDL, and artrogenic index (AI) were assessed. Student's t-test and Pearson correlation test were used in data analysis.
Results: Findings of the study revealed significant decreased effects of the interval training program on SBP, DBP, TC AI, and significant increased effects on VO_2 max and HDL level at P<0.05. There was also a significant correlation between changes VO_2 max and changes in AI.
Conclusions: It was concluded that the interval training program is an effective adjunct nonpharmacological management of hypertension and a means of upregulation of HDL.

Key words: Blood pressure, hypertension, interval exercise, lipid profile

Date of Acceptance: 30-Aug-2011

Introduction

It is a well-established fact that sedentary lifestyle contributes to increased risk of cardiovascular disease especially hypertension. Indeed hypertension is a major independent risk factor for cardiovascular events and renal disease, increasing the risk of myocardial infarction, stroke, and heart failure. However, hypertension and its complications are largely responsible for morbidity and mortality of all age groups.[1,2]

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About 40% of hypertensive patients also have high blood cholesterol levels[3] and factors that increase risk for coronary events in hypertensive individuals included; elevated low-density lipoprotein cholesterol (LDL) or total cholesterol (TC), smoking, impaired glucose tolerance, and reduced high density lipoprotein cholesterol (HDL). Elevation in serum TC concentration confers approximately

Access this article online	
Quick Response Code:	Website: www.njcponline.com
	DOI: 10.4103/1119-3077.94096
	PMID: 22437088

a 1.9-fold increase in the risk of CHD in men and 1.8-fold increase in women.[4]

High levels of HDL may have a protective role against coronary atherosclerosis,[5] because of its role as a lipid scavenger involved in the reverse transport of cholesterol from the peripheral vascular compartment and tissues to the liver for excretion as bile. Though the mechanism for the beneficial roles of HDL-Ch has yet to be completely elucidated, it is thought that lecithin: Cholesterol acyltransferase (L-CAT) and hepatic lipase (HL) facilitate the roles of HDL-C in reverse cholesterol transport from the arterial wall.[6,7] Hypertension has become one of the most powerful predictors of CHD and the risk increased markedly when HBP is accompanied with other risk factors.[8]

Physical inactivity has been established as a major primary risk factor for the development of hypertension.[9,10] Despite the well-known benefits of aerobic training on blood lipid profiles, the effect of the modes of physical training on blood lipid has not been adequately explored. Interval training, for example, which alternates between intensity work and periods of rest, is one of the most widely used methods of physical training in young men and women.[11] Interval training studies using different work: Rest intervals have shown a controversial effect on blood lipid profiles,[11-14] but it is not clear whether equal work rest intervals at moderate intensity physical activity would have more favorable effects on blood lipid profiles particularly in those with existing hypertension.

The purpose of the present study was to determine whether an 8-week program of moderate–intensity interval training with equal work: Rest interval would significantly elevate HDLC and reduce the total cholesterol (TC) and atherogenic index.

Materials and Methods

Research design

In the present study, age-matched randomized double-blind independent groups design was used to determine the influence of the continuous training program on blood pressure, TC, HDL, and AI. Subjects' ages were arranged in ascending order (50–70 years) and then assigned to the interval and control groups in an alternating pattern (age matched). One-week wash-out period was established and pretest (fasting blood sample collection and stress test) was administered to all subjects on the last day of the wash-out period. Following wash-out and pretest, all subjects (interval and control) were placed on antihypertensive (α-methyldopa) drug. The interval group involved in interval training programs for 8 weeks, while the control group remains sedentary during this period; all subjects were on α-methyldopa (aldomet) during the 8-week training and sedentary period) and at the end of the training and sedentary period, Another 1-week wash-out period was establish 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 Mohammed Specialist Hospital Kano, Nigeria. Subjects were fully informed about the experimental procedures, risk, and protocol, after which they gave their informed consent.

Inclusion criteria

Only those who volunteered to participate in the study were recruited. Subjects between the age range of 50 and 70 years with chronic mild-to-moderate and stable (>1 year duration) hypertension (SBP between 140 mmHg and 179 mmHg and DBP between 90 mmHg and 109 mmHg)[15] were selected. Also, only those who had stopped taking antihypertensive drugs or on a single antihypertensive medication were recruited.[16] They were sedentary and have no history of psychiatry or psychological disorders or abnormalities.

Exclusion criteria

Obese or underweight (BMI below 18.5 and above 30 kg/m^2),[17] smokers, alcoholic, diabetic, other cardiac, renal (particularly nephrosclerosis), respiratory disease patients were excluded. Those involved in vigorous physical activities and above averagely physically fit (VO_2 max>27 and >33 ml/kg/min for over 60 and 50 years old respectively) were also excluded.

A total of 323 chronic and stable, essential mild-to-moderate male hypertensive patients satisfied the necessary study criteria. Subjects were aged matched and randomly grouped into experimental (162) and control (161) groups [Figure 1]. They 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[18] as recommended by the human subject protocol. Ethical approval was granted by the Ethical Committee of Kano State Hospitals Management Board.

Pretest procedure

Wash-out Period

All subjects on antihypertensive drugs were asked to stop all forms of medication and in replace, were given placebo tablets (consisted of mainly lactose and inert substance) in a single-blind method.[19,20] All subjects including those not on any antihypertensive medications were placed on placebo tablets for 1 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 antihypertensive drugs/medications. During the wash-out period all subjects were instructed to 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, and in the Department of Physiotherapy of Murtala Mohammed Specialist Hospital (MMSH), Kano between 8:00 am and 10:00 am.

Physiological measurement

Subjects resting heart rate (HR), SBP, and DBP were monitored from the right arm as described by Walker *et al.*,[21] using an automated digital electronic BP monitor (Omron digital BP monitor, Medel 11 EM 403c; Tokyo Japan). These measurements were monitored between 8:00 am and 10:00 am each test day.

Anthropometric measurement

Subjects' physical characteristics (weight [kg] and height[m]) and body composition (body mass index [BMI] ($kg.m^{-2}$) assessment was done in accordance with the standardized anthropometric protocol.[22]

Blood sample collection (Venipuncture method)

Both pre- and posttreatment venous blood samples were obtained between 8:00 am and 10:00 pm after about 12 hour overnight fast (fasting blood sample). Five milliliter syringe was used for blood sample collection, using the procedure described by Bachorik.[23] About 5 ml of blood was drawn from the antecubital vein of each subject under strict antiseptic condition. Blood samples were allowed to coagulate (clot) at room temperature for 1 hour and centrifuged for serum. Serum samples were transferred in to plastic containers (Vials), sealed and labeled. All samples were stored in a refrigerator at −80°C until analysis.[24]

Stress test

The Young Men Christian Association (YMCA) submaximal cycle ergometry test protocol was used to assess subject's aerobic power.[25,26] The YMCA protocol uses two to four 3 minutes stages of continuous exercise, two HR-power output data points will be needed (steady state HR) of between 110 and 150 beat/min. The two steady-state HR were plotted against the respective workload on the YMCA graph sheet. A straight line was drawn through the two points and extended to the subjects predicted maximum HR (220 age). The point at which the diagonal line intersects the horizontal predicted HR max line represents the maximal working capacity for the subject. A perpendicular line was dropped from this point to the baseline where the maximal physical workload capacity was read in kg m min^{-1}, which was used to predict the subjects VO_2 max. This procedure was done for both pre- and posttest stress test.

Test procedure

The test procedure was also conducted in the Department of Physiotherapy of MMSH, Kano between 8:00 am and 10:00 am.

Training program

Following stress test and prior to the exercise training, all subjects in both control and interval groups were reassessed by the physician and were prescribed with aldomet (methyldopa) as necessary. During the training and sedentary period (8 weeks) all subjects in both continuous and control groups were placed on methyldopa according to their prerecruitment doses and responses at 250 mg and 500 mg daily. Aldomet was preferred because it does not alter normal hemodynamic responses to exercise.[27] It is a well tolerated and mostly prescribed antihypertensive drug in Nigeria,[28] particularly Northern Nigeria where the study was conducted and it is also useful in the treatment of mild-to-moderately severe hypertension.[29] Subjects maintain these prescriptions with regular medical consultation and observation through-out the period of training.

The interval group (group 1)

Subjects in the interval group exercised on a bicycle ergometer at a moderate intensity of between 60% and 79% of their HR max reserve that was estimated from 220 minus the age of a subject as recommended by ACSM.[18,19] The starting workload was 100 kg (17 watts) which was increased at a pedal speed of 50 rpm to obtain a HR max reserve 60% was increased in the first 2 weeks to and level up at 79% HR max reserve throughout the remaining part of the training period at a work/rest ratio of 1:1 of 6 minutes each.[18,25] The initial of exercise session was increased from 45 minutes in the first 2 weeks of training to and leveled up at 60 minutes throughout the remaining part of the training. Exercise session of three times per week was maintained throughout the 8-week period of training for the interval group.

The control group (group 2)

Subjects in the control group were instructed not to undertake any vigorous physical activity during the 8-week period of the study.

Lipid profile analysis

Serum lipid for TC and HDL was determined using the commercial enzymatic method (Randox kits and manuals by Randox Laboratory, Antrim, UK). The artergenic index was estimated from the ratio of TC and HDL (TC/HDL).[11]

Posttest procedure

Wash-out period

At the end of the 8-week training period, all subjects were asked to stop α-methyldopa (Aldomet) and were prescribed with placebo tablets in a single blinded method for 1 week in order to get rid of the effect of the methyldopa taken during the training period.

Blood sample collection

Immediately after the posttraining wash-out period, fasting blood samples were collected as previously described.

Posttraining SBP, DBP, VO_2 max, lipid profile analysis/assessment, and stress test were conducted as previously described in the pretest procedures using standardized protocols, techniques, and methods.

All pre- and posttest measurements were recorded on a data sheet. A total of 245 subjects (140 from the interval, and 105 from the control group) completed the 8-week training program. A total of 106 subjects (22 from the interval, and 56 from the control group) had dropped out because of noncompliance, 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: Flow chart].

Statistical analysis

Following data collection, the measured and derived variables were statistically analyzed. The descriptive statistics (means, standard deviations, and % change) of the subjects' physical characteristics, estimated VO_2 max, SUA, cardiovascular parameters were determined. Student's *t*-test and Pearson product moment correlation tests were computed for the variables of interest. In the *t*- and correlation tests, the difference between subjects posttraining and pretraining measurements (changed score) were used as dependent measures. All statistical analysis was performed 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

The subject's age ranged between 45 years and 70 years. The mean age, height, weight, and BMI±SD for the interval group were 58.40 ± 6.91 years, 167.78 ± 7.81 cm, 70.18 ± 11.37 kg, 24.96 ± 3.88 kg/m^2 and for the control group 58.27 ± 6.24 years, 167.89 ± 5.31 cm, 68.47 ± 17.07 kg, 24.16 ± 4.91 kg/m^2. There was no significant difference in age between groups (t=0.156, P=0.876).

Subject's pre- versus posttreatment mean BP±SD mmHg, and VO_2 max ml/kg/min, HDL, TC, and AI for the exercise and control groups are depicted on Table 1. Graphical representation of pre- and posttreatment HDL, TC, and AI is depicted on Figure 2.

Table 2 Student, s *t*-test results indicated a significant reduction in the exercise groups over control in SBP (t=12.056, P=0.000), DBP (t=−7.048, P=0.000), VO_2 max (t=−12.059, P=0.000), TC (t=−12.779, P=0.000) and significant increase in HDL (t=8.011, P=0.000), and AI (t=−9.405, P=0.000) at P<0.05. There was a significant correlation between changes in VO_2 max and changes in AI (r=0.248) as indicated in Figure 3.

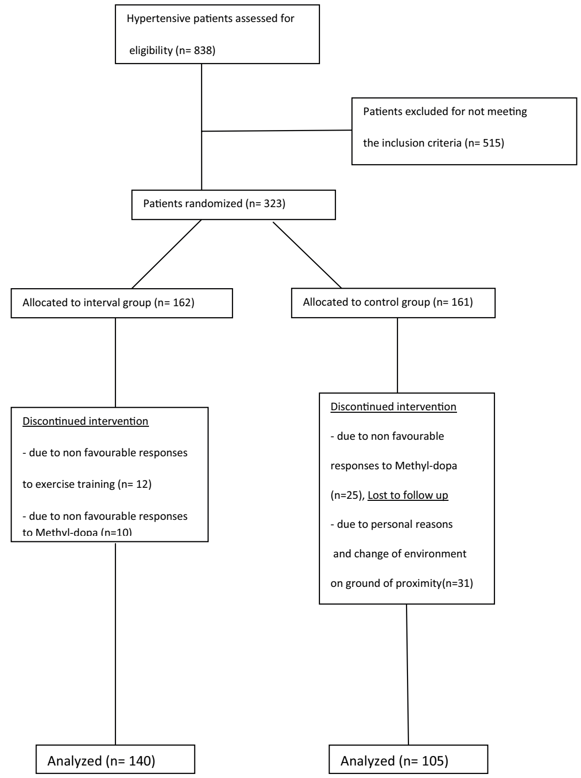

Figure 1: Study design flow chat

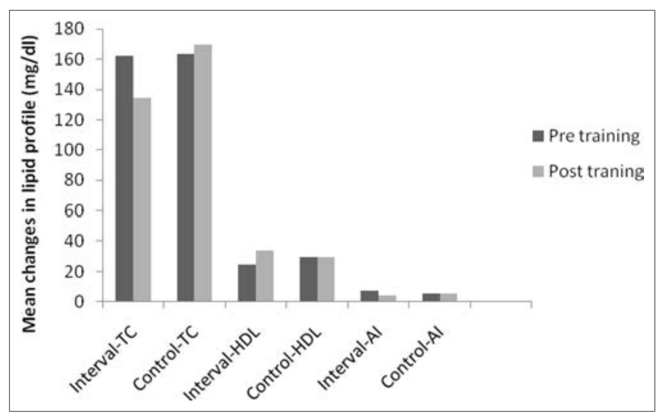

Figure 2: Prepost training changes in the group lipid profile

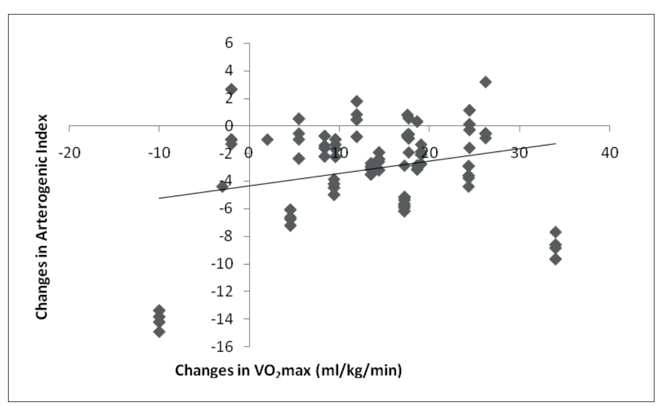

Figure 3: Correlation between training changes in VO_2 max and Arterogenic Index (N=245)

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)	100.80 ± 3.38	94.08 ± 5.31	97.17 ± 7.20	96.10 ± 2.67
VO_2 max (ml/kg/min)	23.67 ± 9.15	37.46 ± 7.42	21.23 ± 5.76	22.82 ± 7.44
HDL (mg/dl)	24.60 ± 8.51	33.81 ± 6.38	29.53 ± 6.55	29.54 ± 6.57
TC (mg/dl)	162.00 ± 49.31	134.10 ± 43.91	163.20 ± 36.61	169.4 ± 35.47
AI	7.27 ± 3.33	4.16 ± 1.77	5.62 ± 1.10	5.84 ± 1.06

N = Total number of subjects, n = Groups number of subjects, SBP = Systolic blood pressure, DBP = Diastolic blood pressure, HDL = High density lipoprotein, TC = Total cholesterol, AI = Artrogenic Index

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

Variables	Changed score values X±SD		t-values	P values
	Interval group n=140	Control group n=105		
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_2 max (ml/kg/min)	13.79 ± 9.99	1.59 ± 3.52	11.959	0.000*
HDL (mg/dl)	9.21 ± 11.76	0.01 ± 0.33	8.011	0.000*
TC (mg/dl)	−27.90 ± 26.45	6.20 ± 7.95	−12.779	0.000*
AI	−3.11 ± 3.61	0.22 ± 0.33	−9.405	0.000*

*P<0.05. N = Total number of subjects, n = Groups number of subjects. r=0.248**, significant at 0.01, **N=total number of subjects

Discussion

The results of this study suggest that 8 weeks of moderate intensity interval training can elicit favorable changes in HDL-C, TC, and the lipoprotein ratio (AI) in men with hypertension. The finding of the present study is in agreement with the report of Tsai *et al.*;[29] they studied the effect of aerobic exercise on blood lipid of mild essential hypertensive patients. Twenty-three Taiwanese hypertensive patients with resting BP (SBP, 139.1 ± 11.14; DBP, 99.5 ± 8 mmHg) were randomly grouped into control (no exercise) and moderate intensity exercise groups (average 6.4 ± 0.7 METs). The training group reported a significant reduction in TC, LDL-C, and TG, and significant increase in HDL-C.

Ferrier *et al.*[30] investigated the effect of aerobic exercise on blood lipids. Twenty (10 males and 10 females) isolated systolic hypertensive (ISH) and 20 age- and gender-matched normal control subjects were recruited. Subjects involved in an eight weeks moderate intensity (60% HR max) exercise for 40 minutes followed by another 8 weeks of sedentary activity. They reported no significant effect of exercise in LDL-C, HDL-C, and TG in ISH patients.

Himeno *et al.*[31] investigated the effect of aerobic exercise on plasma lipid of mild-to-moderate obese hypertensive subjects, 14 mild hypertensive obese subjects, and 22 normotensive obese subjects, subjects on a mild hypocaloric diet exercise (33) on a cycle ergometer and walking on treadmill (3), at an HR corresponding to the anaerobic threshold (AT) for 60 minutes, 3 times per week for a total period of 12 weeks and also maintained the exercise for a 1-year follow-up. They reported a significant decrease in TC/HDL-C and TG following 12 weeks of exercise in the hypertensive group at P<0.01 and P<0.02 respectively. In addition, both TC/HDL-C and TG significantly reduced in the control group at P<0.05. HDL-C reported a significant increase at P<0.001, while LDL-C did not differ significantly in both groups.

Iyawe *et al.*[32] in their own study investigated the effect of exercise on the lipid profile of black African (Nigeria) hypertensives. Fifty-eight hypertensive subjects (aged 30–65 years) exercised on a cycle ergometer for 30 minutes at 70% VO2 max for between 1 and 3 times per week for 16 weeks. They reported a significant slight decrease in TC and LDL-C levels but HDL-C level increased from the onset value of 0.94 mmol/l to 1.38 mmol/l at the end of the exercise training at P<0.05. Filipovsky *et al.*[33] studied the effect of 5-week aerobic physical training course on blood lipids of 77 sedentary hypertensive subjects. They reported significant decrease in TC, TG, HDL-C, at P<0.001, while the HDL/TC ratio increased significantly at P<0.001. These significant changes disappeared between 3 and 7 months after the intervention of exercise training. They concluded that 5-week intensive physical training had a favorable but short-term effect on the lipid profile pattern of subjects with hypertension.

On the contrary, Thomas *et al.*[34] used a similar high interval running protocol (4-minute interval lengths [1:1 work:rest] at 90% HRmax) but failed to show changes in HDL-C or TC in young healthy men. Another previous interval training study[14] with similar training intensity and caloric expenditure did not show increases in HDL-C or improved blood lipid profiles. However, shorter interval lengths (1 minute; 1:3 work:rest) could have been a contributing factor. Several other related studies[14,21,35,36] have also reported controversial results; the differences in findings could be attributed to the differences in exercise intensities, subjects' health status, and pre(baseline) training lipid profile status. The more unfavorable baseline concentrations of HDL-C in our subjects may have allowed for greater increases with training and contributed to the significant improvement, which has been observed previously.[37]

Results of the present study indicate that moderate intensity interval training using equal periods of activity and rest (1:1

work:rest ratio) is capable of reducing blood pressure and elevating HDL and reducing the atherogenic index and TC in men with hypertension. This training method should form an adjunct therapy in the maintenance of a favorable lipid profile and general management of hypertension.

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How to cite this article: Lamina S, Okoye GC. Therapeutic effect of a moderate intensity interval training program on the lipid profile in men with hypertension: A randomized controlled trial. Niger J Clin Pract 2012;15:42-7.

Source of Support: Nil, **Conflict of Interest:** None declared.