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Effectiveness of Interval Versus Continuous Training on Blood Pressure Among Hypertensive Postmenopausal Women

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ABSTRACT

Background: Hypertension is a significant risk factor for cardiovascular disease (CVD) in postmenopausal women. The decline in estrogen levels during menopause contributes to increased oxidative stress, endothelial dysfunction, and heightened sympathetic activity, all of which can elevate blood pressure. Various approaches, including pharmacological and non-pharmacological interventions, are utilized to manage hypertension, with aerobic exercise being a recommended strategy for both prevention and treatment. However, limited research directly compares the effects of interval and continuous aerobic training on blood pressure in hypertensive postmenopausal women. This study aimed to assess the effectiveness of moderate-intensity continuous aerobic training and high-intensity interval aerobic training in reducing blood pressure and body mass index (BMI) in this population.

Methods: This experimental study included 30 postmenopausal women diagnosed with Stage 1 hypertension, randomly assigned to three groups: Group A (moderate-intensity continuous aerobic training), Group B (high-intensity interval aerobic training), and Group C (control group). The intervention lasted six weeks, with training sessions conducted thrice weekly. Blood pressure and BMI were recorded before and after the intervention. Data analysis involved ANOVA and post-hoc tests to examine intra-group and inter-group differences.

Results: Both Group A and Group B showed a significant reduction in systolic and diastolic blood pressure ($p<0.05$). Group B demonstrated a more significant decrease in systolic blood pressure (from 142.7 ± 5.1 mmHg to 127.7 ± 4.6 mmHg, $p<0.05$) compared to Group A (from 140.7 ± 4.4 mmHg to 135.2 ± 4.3 mmHg, $p<0.05$). Similarly, diastolic blood pressure was significantly lower in Group B (from 91.0 ± 3.5 mmHg to 81.7 ± 3.5 mmHg, $p<0.05$) compared to Group A (from 92.3 ± 3.0 mmHg to 88.5 ± 2.7 mmHg, $p<0.05$). BMI reduction was also more pronounced in Group B (from 27.3 ± 1.5 kg/m^2 to 25.3 ± 1.4 kg/m^2, $p<0.05$) than in Group A (from 27.4 ± 1.7 kg/m^2 to 26.6 ± 1.6 kg/m^2, $p<0.05$). No significant changes were observed in Group C.

Conclusion: Both training methods effectively reduced blood pressure and BMI in hypertensive postmenopausal women. However, high-intensity interval training significantly reduced systolic and diastolic blood pressure and BMI more than moderate-intensity continuous training. These findings highlight the potential of interval training as a more efficient approach for managing hypertension in postmenopausal women.

Keywords: Hypertension, Postmenopausal Women, Interval Training, Continuous Training, Blood Pressure, Cardiovascular Health.

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INTRODUCTION

The Joint National Committee on Prevention, Detection, Evaluation, and Treatment of Hypertension has reported hypertension as an increasingly important medical and public issue. According to this report, a systolic blood pressure of more than 140 mmHg is an important CVD risk factor in those older than fifty [1]. Coronary heart disease is the leading cause of death among postmenopausal women in the Western world [2]. Hypertension is the primary cause of CVD in postmenopausal women. Menopause represents a key transition period in a woman's health. Menopause is defined as a natural age-related decrease and, finally, loss of ovarian estrogen production and secretion [3]. Hypertension is more prevalent in men than women up to the age of 55; however, after 55, the percentage of women affected surpasses that of men. The rapid rise in cardiovascular disease (CVD) among women who have undergone natural or surgical menopause has been associated with estrogen deficiency.

According to Joint National Commission guideline 7, hypertension can be defined as a systolic blood pressure higher than 140 mmHg and diastolic pressure beyond 89 mm Hg on two or three separate readings. It can be measured as an average of 2-3 separate measurements. It classified hypertension into three stages, which include pre-hypertensive, stage l, and stage 2 hypertensives [4]. Premenopausal women have lower blood pressure than men, and women have higher rates of hypertension than men as they age [5]. These findings suggest that gender or sex hormones have a prominent role in hypertension.

Sex hormones and postmenopausal hypertension are closely related. Menopause is associated with a reduction in estradiol and a decrease in the estrogen-to-testosterone ratio. This results in endothelial dysfunction and an increase in body weight and body mass index (BMI), which causes an increase in sympathetic activation. Sympathetic activation can result in increased renin release and an increase in angiotensin II (Ang II).

Endothelial dysfunction is accompanied by reductions in nitric oxide and increases in endothelin, both of which contribute to salt sensitivity of BP, which is common in postmenopausal women. The increase in Ang II and endothelin and the reduction in Nitric oxide may lead to increased oxidative stress. The Synergist increase in Ang II can enhance endothelin levels, causing a reduction in nitric oxide and thus stimulating the production of reactive oxygen species (ROS), thus increasing oxidative stress, collectively causing impaired renal function and contributing to hypertension. The decreasing estrogen level and other related hormonal changes induce inactivity in women; bone mineral density is reduced, and aerobic fitness, muscle strength, and balance [6]. Physical activity might help to pass the menopausal transition with much less dramatic changes and help to preserve good functional capacity. Some reports show the complexity of the interaction between physical activity, health, fitness, and hormone [7,8]. Higher levels of physical activity and fitness appear to reduce all-cause mortality and cardiovascular disease mortality in postmenopausal women [9].

Non- Modifiable risk factors for high blood pressure in post-menopausal women are race and heredity, while modifiable risk factors, for instance, obesity, stress levels, sodium intake, and physical inactivity, are leading risk factors for stroke, congestive heart failure, angina, renal failure, & myocardial infarction at all ages and are present in both sexes.

Hypertension management consists of two types of approaches: pharmacological and non-pharmacological. Pharmacological approaches include antihypertensive therapy, mainly thiazide, calcium channel blockers, beta-blockers, and angiotensin-converting enzymes. Non-pharmacological approaches include lifestyle modifications such as diet modification, quitting smoking, and salt reduction. Weight loss, especially loss of abdominal adipose tissue, increased physical activity, and hormonal replacement therapy can reverse changes. Physical exercise is thus strongly recommended in both primary and secondary prevention.

Epidemiological evidence suggests that activity performed regularly, even in several sessions a day, influences health outcomes if total energy expended is sufficient, showing that interval training is as good as continuous training. Other studies comparing fractionated versus continuous exercises on CHD risk factors, such as lipid and blood pressure in postmenopausal women, showed significant results [11].

Rognmo et al. (2004) worked on high-intensity interval exercise compared to moderate-intensity exercise in improving the aerobic capacity of patients with coronary artery disease [12]. They showed that interval training is superior to moderate-intensity exercises in improving aerobic capacity [13].

Howley et al. (2001) investigated the impact of interval training on ventilatory response thresholds and cardiorespiratory outcomes in elderly individuals. Their findings suggest that for untrained older adults, an interval training program conducted at the intensity of the ventilatory threshold is both clinically well-tolerated and effective in enhancing maximal aerobic capacity and submaximal exercise tolerance [14].

Various studies have been done on the comparison of continuous aerobic and interval training. Still, there is a lack of literature regarding studies done on Postmenopausal women. If at all done, none of these studies focus on blood pressure, which is a major contributor to mortality in postmenopausal women, so this study focuses on studying the impact of interval and continuous training on blood pressure in postmenopausal women.

MATERIALS AND METHODS

Study Participants

This experimental study was designed with three parallel groups. Group A received moderate-intensity continuous aerobic training, Group B received high-intensity interval aerobic training, and Group C served as the control group. A total sample of 30 patients with controlled hypertension volunteered to participate in the study conducted in Faridabad. Each subject was initially screened using the Physical Readiness Questionnaire (PAR-Q), and those who answered "yes" to any question underwent a further PAR medical examination, approved by a physician, to confirm eligibility. Participants were included in the study if they met specific inclusion criteria: they were clinically diagnosed with Stage 1 hypertension, were on antihypertensive medication, were postmenopausal women who had reached menopause at least two years prior, and were aged between 48 and 58. Additionally, participants needed to have a BMI between 24.5 and 29.9 kg/m^2, a hypertension diagnosis duration of no less than six months and no more than three years, and have been on a stable hypertension medication regimen for at least a month before recruitment.

Specific exclusion criteria were also applied. Participants with uncontrolled hypertension, those on beta-blockers, or those engaged in regular exercise programs in the six months before the study were excluded. The study further excluded individuals with a history of cardiac disorders (other than hypertension), neurological issues, orthopedic problems, multiple organ failure, metabolic diseases, or pulmonary disorders.

Methodology

Subjects were explained the purposes, risks, benefits, and procedure of the study before of 30 patients with stage 1they were randomized to the various study groups. An informed consent was taken. All the subjects were assessed thoroughly using an assessment Performa so that any other abnormalities could be ruled out. Total hypertension in the age group between 48-58 years and was randomly assigned to groups using a permuted block randomization list. Subjects were distributed equally into three groups in sequential order. Subjects were allocated in 3 groups in sequential order. Subjects were allocated in 3 groups, 10 each. Group A: Moderate continuous aerobic training, Group B: High-intensity interval aerobic training. And Group C: Control group.

Protocol

The study was conducted for 6 weeks, during which continuous and interval aerobic training was given. A study program included a total of 18 sessions. Each training session was performed on three alternate days. Heart rate and blood pressure were measured at baseline and then rerecorded between the exercise session and after completion of each session, and a final reading was taken after 6 weeks. After the patient's arrival, all the vitals, including respiratory rate, temperature, blood pressure, and heart rate, were thoroughly assessed. These were assessed after 3 min of rest after arrival. Two B.P. readings were taken, and their mean was recorded. Participants were instructed to report symptoms like dyspnoea, fatigue, dizziness, etc. Additionally, the RPE scale was explained to ensure that the participants could gauge the level of exertion and maintain the desired intensity.

Instructions regarding the maintenance of a specific level of exertion (i.e., light to somewhat hard) were also provided to maintain a moderate intensity of exercise as per the requirements of our study. In between the performance of exercise sessions, heart rate and BP were re-recorded to be within the safe exercise limit. The readings of these parameters were also taken immediately after an exercise session, after 1 minute, after 3 minutes, and after 5 minutes of an exercise session.

Continuous aerobic exercise protocol

Patients in this group exercised on a stationary bicycle for 30-40 minutes. Each session was done 3 days per week on alternate days for 6 weeks. Speed was determined by the patient's perception of RPE. Omron heart rate monitor was used in between to be within a safe limit.

Initially, subjects were given a 10-minute warm-up phase that included low-intensity stationary bicycling. Then, the conditioning phase was performed using moderate-intensity bicycling for 15 minutes, followed by 10 minutes of low-intensity bicycling as a cool-down session phase.

The RPE level of light (11 on RPE) to somewhat challenging (13 on RPE) was used for moderate exercise, and for intensity of exercise, heart rate was used for the safe exercise limit as recommended by ACSM guidelines for stage-1 hypertension patients. Separate maximal heart rate calculations were done according to 220—age for every individual to specify a safe heart rate limit. Exercise is done at moderate intensity (60-75% of PMHR) and low intensity (40-60% of PMHR).

The total phase duration was kept between 30 and 40 minutes. The duration of warm-up and cool-down was initially 5 minutes and extended up to 10 minutes. The duration of the aerobic phase was between 15 and 25 minutes. It started at 15 minutes and then gradually increased by 2 minutes after every second session until it reached 25 minutes by decreasing the duration of warm-up and cool-down phases, keeping the whole duration between 30 and 40 minutes.

Interval aerobic exercise protocol

Patients in this group also exercised on a stationary bicycle for 30-40 minutes. Each session was done 3 days per week on alternate days for a total duration of 6 weeks. Speed was determined by the patient's perception of RPE. Initially, subjects were given a warm-up phase of 10 minutes, which included low bicycling as a cool-down phase of the session. Moderate-intensity bicycling for 15 minutes, followed by 10 minutes of low-intensity stationary bicycling. Then, the conditioning phase was performed using the intensity. The patient was instructed to work at an alternate session of 3 minutes of low Total time in the aerobic session was divided into various sessions of low and high y, and 4 minutes of high-intensity RPE was maintained at (11-13) for 3 minutes and (17-19) RPE for 4 minutes. Then, the high-intensity session is increased gradually after 2 weeks of aerobic training.

Figure 1: Participant performing high-intensity interval training.

RESULTS

A total of 30 participants were included in the study, with demographic characteristics summarized in Table 1.

Table 1: Demographic Characteristics of Participants

Variables	Group A (n=10)	Group B (n=10)	Group C (n=10)
Age (Mean ± SD)	43.5	45.2	44.2
BMI (Mean ± SD)	27.4	27.3	27.3

Systolic Blood Pressure

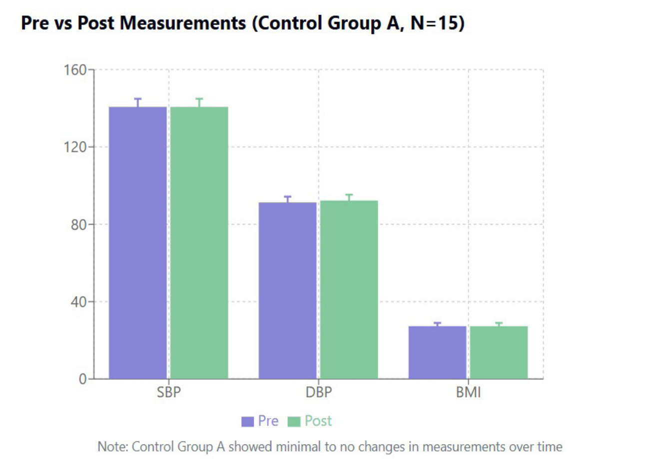
ANOVA was performed for the intra-group analysis of the systolic blood pressure. There was a significant change in systolic blood pressure from pre to post in Group A (0.05) and Group B ($p<0.05$). This implies that both interval and continuous exercises are effective in reducing the systolic blood pressure values in pre and mild hypertensive patients (Refer to Table.2)

A post hoc test was performed to evaluate the significance of the change in systolic blood pressure values from baseline between the two groups. There was a significant difference in systolic blood pressure, with improvement seen in one group. ($p<0.05$). This suggests that interval aerobic exercises are more effective in reducing systolic blood pressure. (Refer to Table no. 2).

Table 2: Comparison of Pre- and Post-exercise Systolic Blood Pressure.

Systolic Blood Pressure	Pre-Exercise			Post Exercise		
	Mean	Std Deviation	F value	Mean	Std Deviation	F value
Group A	140.7	4.4	0.6	135.2	4.3	13.9
Group B	142.7	5.1	0.6	127.7	4.6	13.9
Group C	141.9	7.7	0.6	141.9	7.7	13.9

Figure 2: Shows Comparison of Pre and Post Value in Three Groups



Diastolic Blood pressure

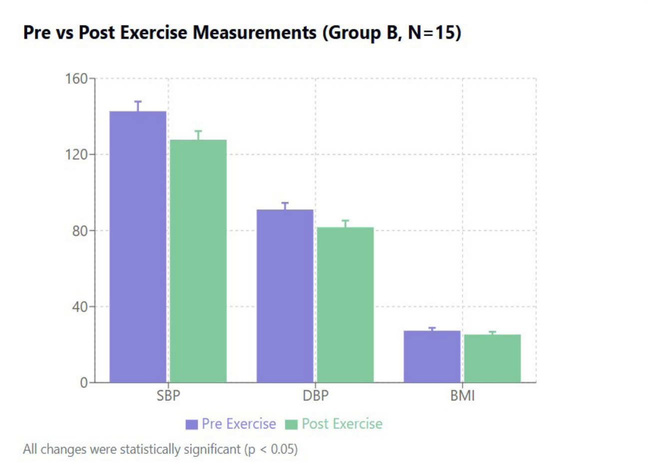
ANOVA was performed for the intra-group analysis of the diastolic blood pressure. There was a significant change in diastolic blood pressure from pre to post in Group A ($p<0.05$) and Group B ($p<0.05$). This implies that both exercises are effective in reducing the diastolic blood pressure values in pre and mild hypertensive patients (Refer to Table.3)

A post hoc test was used to evaluate the significance of the change in diastolic blood pressure values from baseline between the two groups. The interval aerobic group had a more significant change in diastolic blood pressure. This implies that interval aerobic training has a more beneficial effect than continuous aerobic training in reducing diastolic blood pressure.

Table 3: Comparison of Pre- and Post-exercise Systolic Blood Pressure.

Diastolic Blood Pressure	Pre Exercise			Post Exercise		
	Mean	Std Deviation	F value	Mean	Std Deviation	F value
Group A	92.3	3	0.6	88.5	2.7	16
Group B	91	3.5	0.6	81.7	3.5	16
Group C	90.2	4.1	0.6	90.2	5.62	16

Figure 3: Comparison of Pre and Post exercise Diastolic Blood Pressure



Metabolic Rate (BMI)

Intra-group analysis was performed to evaluate diastolic blood pressure. There significant change in BMI from pre to post in Group A ($p<0.05$) and Group B ($p<0.05$) mild hypertensive patients. This implies that both exercises are effective in pre and mild, reducing the BMI values in pre and mild hypertensive patients.

A post hoc test was done to evaluate the significance of the change in BMI values from baseline Between the two groups. The interval aerobic group had a more significant change in BMI values ($p\geq0.05$). This implies that interval aerobic training has a more beneficial effect than continuous aerobic group regarding reduction in BMI. (Refer to Table.4)

Table 4: Comparison of Pre and Post exercise BMI

BMI	Pre-Exercise			Post Exercise		
	Mean	Std Deviation	F value	Mean	Std Deviation	F value
Group A	27.4	1.7	0.6	26.6	1.6	4.9
Group B	27.3	1.5	0.6	25.3	1.4	4.9
Group C	27.3	1.4	0.6	27.3	1.4	4.9

The results were found to be significant, with an F value of more than 2 and a probability value of $p <0.001$, which is highly statistically significant. This suggests that there were significant differences in the three different groups of aerobic exercises.

Post hoc analyses were done using a test to perform multiple comparisons with the different forms of aerobic exercises. Compared to continuous aerobic training interval, aerobic training was found to be more sensitive and statically significant in acing blood pressure in hypertensive postmenopausal women at a $p < 0.05$, which is statistically significant.

Figure 4: Representation of Pre and Post Data Pre and Post-Exercise

DISCUSSION

The present study demonstrated a significant reduction in systolic and diastolic blood pressure among hypertensive postmenopausal women aged 48 to 58 who participated in structured exercise programs compared to non-exercising controls. The reduction in systolic blood pressure was 7.85%, while diastolic blood pressure decreased by 7.15% in the exercising group. Additionally, a 5.28% decrease in BMI was observed among exercising individuals, whereas no such significant change was found in the BMI of the non-exercising group. These findings support that physical activity is inversely related to blood pressure (Pescatello et al., 2004) [17].

The mechanisms underlying the reduction in blood pressure due to exercise are not entirely understood, but several physiological adaptations have been proposed. Pescatello et al. (2004) suggested that neurohumoral, vascular, and structural adaptations contribute to blood pressure reduction [17]. These adaptations include decreased catecholamine levels, improved insulin sensitivity, altered vasodilatory and vasoconstrictive responses, and reduced total peripheral resistance. Jennings et al. (1986) highlight that exercise training reduces sympathetic nervous system activity, lowering plasma norepinephrine levels [19]. Additionally, regular physical activity decreases the activity of the renin-angiotensin system, particularly reducing renin and angiotensin II levels, contributing to blood pressure reduction (Haskell et al., 2007) [18]. Furthermore, vascular adaptations, including attenuation of alpha-adrenergic receptor stimulation, have been observed after consistent exercise training (Shephard & Balady, 1999) [9].

Aging is known to have detrimental effects on the cardiovascular system, often leading to increased blood pressure. However, moderate to vigorous physical activity can counteract these effects by producing age-specific physiological improvements (Kelley & Kelley, 1999) [21]. These improvements include a reduction of approximately 2 mmHg in both systolic and diastolic blood pressure. Staessen et al. (1997) further reported that postmenopausal women are more likely to develop hypertension than their premenopausal counterparts, even after adjusting for age and BMI [4].

The physiological basis of aerobic training-induced blood pressure reduction has been explored in various studies. Mazzeo et al. (1998) evaluated the role of training-induced increases in stroke volume and arteriovenous oxygen difference (a-VO2) in improving aerobic fitness [7]. They found that men experience both an increase in stroke volume (15%) and a higher a-VO2 difference (7%). In contrast, improvements in VO2 max are primarily due to an increased a-VO2 difference in women, suggesting that older women rely more on peripheral adaptations in trained muscles.

In the present study, the interval aerobic exercise group exhibited the most significant reductions in systolic

(10.50%) and diastolic (10.2%) blood pressure. These results align with findings from Nemoto et al. (2007), who reported a 9-mmHg reduction in systolic blood pressure and a 5 mmHg decrease in diastolic blood pressure following interval training [16].

High-intensity interval training (HIIT) has emerged as a particularly effective strategy for blood pressure management. Blair et al. (2019) conducted a retrospective study spanning 1 to 12 years, examining men and women aged 20 to 65 with no history of hypertension. [18] Their findings indicated that individuals with lower VO2max levels had a significantly higher risk of developing hypertension compared to those with higher VO2max (Wisløff et al., 2007) [22].

Rognmo et al. (2004) further supports our study's results. They found significant reductions in systolic and diastolic blood pressure across different exercise regimens [12]. Notably, the reductions were more pronounced in the interval training group. These findings suggest that HIIT may be a superior modality for blood pressure management among hypertensive postmenopausal women.

CONCLUSION

In this study, thirty subjects with stage-1 hypertension were given different modes of exercise. Interval aerobic exercises are more effective than continuous aerobic exercises in lowering blood pressure among hypertensive postmenopausal individuals.

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