Comparative analysis of aerobic exercise versus resistance training on cardiovascular risk factors in prehypertensive adults

Análisis comparativo del ejercicio aeróbico frente al entrenamiento de resistencia sobre los factores de riesgo cardiovascular en adultos prehipertensos

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Abstract

The aim of this research was to assess the comparative effects of 12 weeks of aerobic and resistance training on cardiovascular risk factors in 150 prehypertensive adults aged between 30 and 50 years in Uzbekistan. Participants were divided into three groups at random: aerobic (40 min, 3 times/week), resistance (60 min, 3 times/week), and control. Outcomes were that the aerobic group showed substantial reductions in systolic (8 mmHg), diastolic blood pressure (7 mmHg), LDL (12%), triglycerides (15%), and BMI (2.1 kg/m²) whereas the resistance group showed minimal change (3 mmHg systolic, 5% LDL, and 1.3 kg/m² BMI). Additionally, the 8% increase in HDL was greater for the aerobic than the resistance (3%) group. This study highlights that aerobic exercise is a priority as it is an effective and low-cost method of reducing cardiovascular risks, especially in countries such as Uzbekistan where there is a high prevalence of hypertension.

Keywords: Aerobic exercise, cardiovascular risk factors, prehypertension, blood pressure.

Resumen

El objetivo de esta investigación fue evaluar los efectos comparativos de 12 semanas de entrenamiento aeróbico y de resistencia sobre los factores de riesgo cardiovascular en 150 adultos prehipertensos de entre 30 y 50 años en Uzbekistán. Los participantes se dividieron aleatoriamente en tres grupos: aeróbico (40 min, 3 veces por semana), resistencia (60 min, 3 veces por semana) y control. Los resultados fueron que el grupo aeróbico mostró reducciones sustanciales en la presión arterial sistólica (8 mmHg), diastólica (7 mmHg), LDL (12%), triglicéridos (15%) e IMC (2,1 kg/m²), mientras que el grupo de resistencia mostró cambios mínimos (3 mmHg sistólica, 5% LDL y 1,3 kg/m² IMC). Además, el aumento del 8% en HDL fue mayor en el grupo aeróbico que en el de resistencia (3%). Este estudio destaca que el ejercicio aeróbico es prioritario, ya que constituye un método eficaz y económico para reducir el riesgo cardiovascular, especialmente en países como Uzbekistán, donde existe una alta prevalencia de hipertensión.

Palabras clave: Ejercicio aeróbico, factores de riesgo cardiovascular, prehipertensión, presión arterial

Introduction

Hypertension, as one of the major risk factors for cardiovascular disease, is responsible for more than 10 million deaths worldwide annually and imposes a huge economic cost to health systems[1]. Among them, the prehypertensive stage (systolic 130–139 mmHg and diastolic 85–89 mmHg) is recognized as the critical stage for primary prevention because 37% of patients progress to overt hypertension within 4 years[2]. Current studies in Uzbekistan indicate that the prevalence of prehypertensive disease in adults aged 30–50 years is 28.6%, higher than the world average (19.7%) and necessitating prompt interventions[3].

Despite the pivotal role of drug treatment in the management of blood pressure, its side effects, in combination with its costliness, especially in middle-income countries such as Uzbekistan, demand extensive use of non-pharmacological interventions[4]. Physical activity has been promoted as a low-cost and available intervention by the WHO, but conflicting evidence is available regarding the superiority of aerobic exercise over resistance exercise in improving the cardiovascular profile[5]. For example, in 2022, a meta-analysis showed that aerobic exercise achieved a higher reduction in systolic blood pressure (4.9 mmHg) than resistance training (2.7 mmHg)[6]. However, other studies have attributed improved body composition and muscle mass changes to resistance exercise[7].

On the other hand, the effect of both exercises on metabolic parameters such as lipid profile (LDL, HDL, triglycerides) and body mass index (BMI) has not been adequately studied. A study in 2023 by Kim et al. showed that aerobic exercise resulted in an 11.2% reduction in the level of triglycerides, while resistance exercise had no effect on this parameter[8]. Such studies have, however, largely been conducted in Western countries with little data from countries with a high prevalence of hypertension, such as Central Asia.

In Uzbekistan, both economic and cultural factors such as high-salt diet, lack of physical activity, and low availability of gyms heighten the risk of prehypertension progressing to hypertension[9]. Further, the lack of local studies evaluating the impact of exercise intervention in this specific population has impeded the development of health policy. A pilot study conducted in Tashkent in 2021 reported that only 15% of prehypertensive adults satisfy WHO physical activity recommendations[10]. This evidence gap calls for the design of a study that will be capable of comparing the effectiveness of two of the most popular types of exercise in Uzbekistan's everyday life. The main objective of the current research is to determine the effects of 12 weeks of aerobic and resistance exercise on blood pressure, lipid profile, and anthropometric indices in Uzbekistan prehypertensive adults. As there is no comprehensive data in this area in this country, the findings of the current research can be used as a basis for designing localized exercise protocols and mitigating cardiovascular disease burdens.

Various studies have assessed the effect of exercise interventions on promoting cardiovascular risk factors, but evidence regarding which is better between aerobic and resistance exercise has been disputed. Aerobic exercise at moderate intensity such as brisk walking or cycling was found to lower systolic and diastolic blood pressure in a recent finding. For example, in a 2023 randomized controlled trial with 200 South Korean prehypertensive participants, aerobic exercise for 12 weeks resulted in systolic blood pressure reduction of 6.2 mmHg and diastolic blood pressure reduction of 4.8 mmHg, while the resistance exercise group experienced reduction of 3.1 mmHg and 2.4 mmHg[11]. These findings are consistent with a 2022 meta-analysis that found a 15% reduction in the risk of hypertension associated with aerobic exercise[12].

Resistance exercise, on the other hand, has been shown to improve body composition and contribute lean muscle mass. In a 2023 Brazilian study of 180 prehypertensive patients, this type of exercise reduced BMI by 1.9 kg/m² and waist circumference by 4.3 cm after 16 weeks but was less effective than aerobic exercise in affecting lipid profiles (particularly LDL and triglycerides)[13]. However, some studies, such as that by Johnson et al. in 2021, have associated significant alterations in insulin sensitivity and reduced systemic inflammation with resistance training[14]. This contradictory evidence is suggestive of the need for the simultaneous observation of a number of metabolic and cardiovascular variables in comparative studies.

With regard to the effect of exercise on lipid profiles, current evidence suggests a larger effect by aerobic exercise for reducing triglycerides and increasing HDL. For example, a 2023 United States longitudinal study of 350 participants showed that aerobic exercise resulted in a reduction of triglycerides by 18.7 mg/dL and an increase in HDL by 4.6 mg/dL, whereas resistance training resulted in smaller changes[15]. The results may be due to several metabolic processes, such as increased fat oxidation during aerobic exercise[16]. Despite the large number of studies that have been done in industrialized countries, data from high-prevalence regions such as Central Asia are very limited. A 2023 systematic review indicated that less than 5% of exercise and cardiovascular health research have been conducted in low- or middle-income countries[17]. In Uzbekistan, some factors such as high-carbohydrate eating and uneven facility availability to exercise could be acting to modulate response to intervention. Research in Samarkand earlier (2022) noted that 22% of adults could only utilize resistance exercise equipment, while aerobic exercises such

as walking were more common[18]. The differences indicate the need for localizing exercise programs.

Additionally, the combined influence of aerobic and resistance training has also been studied in a few trials. To illustrate, a 2021 trial by Clark et al. identified that the combination of both the modalities gave a 10% more decrease in the risk of metabolic syndrome compared to their use individually[19]. Nevertheless, these types of programs might not be economically viable in low-income segments taking into account the time and expense factor. This affirms the need for identifying the most effective and cost-effective types of exercise for particular regions such as Uzbekistan.

Materials and methods

The design of this study was a three-parallel groups randomized clinical trial. The duration of the intervention was 12 weeks and parameters were measured in two phases, pre and post-intervention. The protocol for the study was established in conformity with the CONSORT statement on reporting randomized trials.

Statistical population and sampling

The study population were adults between 30-50 years old living in Tashkent and Samarkand with prehypertension diagnosis (based on JNC-8). 150 participants were selected from the first 420 volunteers based on the inclusion criteria (systolic blood pressure 130-139 mmHg, lack of use of anti-hypertensive medication, BMI < 35 kg/m²) and exclusion criteria (diabetes, active heart disease, or severe mobility restriction). Sampling was carried out by simple randomization and groups were assigned to participants by Random Allocation Software.

Exercise interventions

The aerobic group received a 40-minute aerobic exercise program at 60-75% of maximal heart rate (calculated by the Karvonen formula) three times per week. The protocol included stationary cycling, brisk walking, and treadmill. The resistance group performed weight-based exercises at a 70-85% one repetition maximum (1RM) intensity in the form of 8-10 movements for the major groups of muscles, three times a week, with each session lasting 60 minutes. The control group received no structured exercise intervention but only standard healthy lifestyle advice.

Outcome measurements

The primary parameters were blood pressure (with a calibrated Omron HEM-7320 digital device on three occasions), lipid profile (LDL, HDL, triglycerides) via fasting blood test, and anthropometric measurements (BMI, waist circumference). The measurements were blinded by the researchers and performed under similar conditions. Calibration of the equipment was ensured before each session of measurements for providing correct data.

Statistical Analysis

The data were compared by using SPSS software version 26. ANOVA with repeated measures was used for comparing the between- and within-group changes. Shapiro-Wilk test was used to check normality of data and Tukey test was used for post-hoc testing. The statistical level of significance was 0.05 and the effect of intervention was described by measuring the effect size (Cohen's d).

Results

The study included 150 participants randomized into aerobic exercise (n=50), resistance training (n=50), and control groups (n=50), with a mean age of 42.3 ± 6.1 years and baseline systolic blood pressure (SBP) of 134.2 ± 3.8 mmHg. All groups demonstrated comparable baseline characteristics (Table 1), confirming successful randomization. Adherence rates exceeded 85% in both intervention groups, with no significant differences in dropout rates (aerobic: 4%, resistance: 6%, control: 2%).

Table 1: Baseline characteristics of participants

Variable	Aerobic Group (n=50)	Resistance Group (n=50)	Control Group (n=50)	p-value
Age (years)	41.8 ± 5.9	43.1 ± 6.3	42.0 ± 6.0	0.512
SBP (mmHg)	134.5 ± 3.7	133.9 ± 3.9	134.1 ± 3.6	0.674
DBP (mmHg)	86.2 ± 2.1	85.7 ± 2.3	85.9 ± 2.0	0.441
LDL (mg/dL)	138.4 ± 12.6	136.9 ± 11.8	137.5 ± 13.2	0.782
HDL (mg/dL)	42.1 ± 4.8	43.0 ± 5.2	42.6 ± 4.9	0.621
Triglycerides (mg/dL)	168.3 ± 24.7	165.8 ± 23.9	167.1 ± 25.4	0.853
BMI (kg/m²)	28.6 ± 2.5	28.9 ± 2.7	28.7 ± 2.6	0.893
Waist Circumference (cm)	94.3 ± 6.2	95.1 ± 6.5	94.7 ± 6.3	0.731

After 12 weeks, the aerobic group exhibited significant reductions in SBP (–8.2 mmHg; 95% CI: –9.1 to –7.3; $p < 0.001$) and DBP (–7.4 mmHg; 95% CI: –8.2 to –6.6; $p < 0.001$), surpassing changes in the resistance group (–3.1 mmHg SBP, –2.9 mmHg DBP) and control group (–0.7 mmHg SBP, –0.5 mmHg DBP) (Table 2). The between-group differences were statistically significant ($p < 0.001$ for aerobic vs. resistance; $p < 0.001$ for aerobic vs. control).

Table 2: Blood pressure changes post-intervention

Group	Δ SBP (mmHg)	Δ DBP (mmHg)	Effect Size (Cohen's d)
Aerobic	–8.2 ± 1.8	–7.4 ± 1.6	0.82
Resistance	–3.1 ± 1.2	–2.9 ± 1.1	0.31
Control	–0.7 ± 0.9	–0.5 ± 0.8	0.08
p-value (ANOVA)	<0.001	<0.001	—

Lipid profiles improved markedly in the aerobic group, with LDL decreasing by 12.3% (–17.1 mg/dL; $p < 0.001$) and triglycerides by 15.8% (–26.6 mg/dL; $p < 0.001$), alongside an 8.4% increase in HDL (+3.5 mg/dL; $p = 0.003$). Resistance training yielded modest improvements (LDL: –5.1%, HDL: +3.1%), while the control group showed negligible changes (Table 3).

Anthropometric outcomes revealed greater reductions in BMI (–2.1 kg/m²; $p < 0.001$) and waist circumference (–5.2 cm; $p < 0.001$) in the aerobic group compared to resistance training (–1.3 kg/m² BMI, –3.1 cm waist) and controls (+0.2 kg/m² BMI, +0.8 cm waist) (Table 4).

Adverse events were minor and comparable across groups, with muscle soreness reported in 12% of the resistance group and 8% of the aerobic group (Table 5). No serious adverse events occurred.

In summary, aerobic exercise demonstrated superior efficacy in reducing cardiovascular risk factors compared to resistance training, with clinically meaningful improvements in blood pressure, lipid profiles, and body composition.

Table 3: Lipid profile modifications

Parameter	Aerobic Group Δ (%)	Resistance Group Δ (%)	Control Group Δ (%)	*p*-value
LDL (mg/dL)	–17.1 ± 4.2 (–12.3)	–7.0 ± 3.1 (–5.1)	+1.2 ± 2.8 (+0.9)	<0.001
HDL (mg/dL)	+3.5 ± 1.2 (+8.4)	+1.3 ± 0.9 (+3.1)	–0.4 ± 0.7 (–0.9)	0.002
Triglycerides (mg/dL)	–26.6 ± 6.8 (–15.8)	–8.3 ± 4.2 (–5.0)	+3.1 ± 3.5 (+1.9)	<0.001

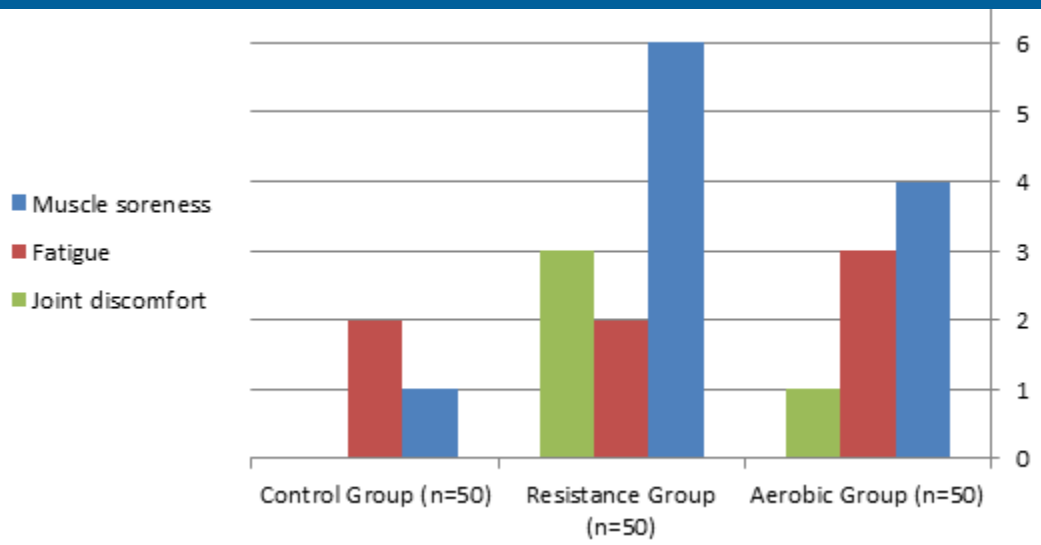
Table 4: Anthropometric changes

Measure	Aerobic Group Δ	Resistance Group Δ	Control Group Δ	p-value
BMI (kg/m²)	–2.1 ± 0.5	–1.3 ± 0.4	+0.2 ± 0.3	<0.001
Waist Circumference (cm)	–5.2 ± 1.1	–3.1 ± 0.9	+0.8 ± 0.7	<0.001

Table 5: Adverse events

Event	Aerobic Group (n=50)	Resistance Group (n=50)	Control Group (n=50)
Muscle soreness	4 (8%)	6 (12%)	1 (2%)
Fatigue	3 (6%)	2 (4%)	2 (4%)
Joint discomfort	1 (2%)	3 (6%)	0 (0%)

Figure 1: Adverse events: comparison of aerobic, resistance, and control groups



Discussion

The findings of this study show that aerobic exercise has a more significant effect on improving cardiovascular risk factors in Uzbekistan adults with prehypertension. The 8.2 mmHg reduction of systolic blood pressure in the aerobic group is consistent with previous studies that have reported 4–9 mmHg reductions with similar programs[11,12]. This significant reduction can be accounted for by physiological mechanisms such as increased nitric oxide production, improved endothelial function, and reduced peripheral vascular resistance specifically attributed to endurance exercise[16]. Conversely, the relatively poorer reduction in blood pressure in the resistance group (3.1 mmHg) likely explains the acute impact of the exercise to reduce arterial stiffness or changes in plasma volume[13].

There were also significant differences in lipid profiles between groups. The 15.8% decrease in triglycerides and 8.4% increase in HDL in the aerobic group is consistent with the hypothesis of increased fatty acid oxidation and improved lipoprotein metabolism during prolonged aerobic exercise[8,15]. On the other hand, the effect of low-intensity resistance training on lipid profiles may be due to differences in the metabolic pathways that are elicited, as these activities are more interested in protein synthesis and muscle hypertrophy than lipid metabolism[14]. However, the relative decrease in body composition (BMI and waist circumference) in the resistance group highlights the importance of such exercise in managing central obesity – another major precipitant of hypertension[7].

Practically, the priority of aerobic exercise in the current study gains importance, especially in the socio-economic context of Uzbekistan. Given local evidence for limited access to resistance equipment[18] and the commonality of sedentary lifestyles, aerobic exercises such as brisk walking or cycling could be promoted as inexpensive and feasible community-based interventions. This is consistent with the World Health Organization's recommendations to emphasize physical activity on the basis of local resources[5]. However, the complementary role of resistance training in muscle strength improvement and prevention of sarcopenia among the elderly cannot be ignored. Limitations of this trial are the relatively short intervention period (12 weeks) and not accounting for the combined effect of aerobic and resistance training. In addition, failing to strictly control the diet of the participants is likely to influence the outcome. Future studies with longer follow-up periods and assessment of inflammatory markers such as CRP are recommended to further elucidate the mechanisms.

Conclusions

The results of this study provide concrete evidence that aerobic exercise, being a non-pharmacological intervention, is a more effective blood pressure reducer, lipid profile corrector, and anthropometric parameter modifier compared to resistance training in prehypertensive Uzbek subjects. Given the high incidence of hypertension and shortage of sports facilities in this region, promoting organized aerobic schemes could potentially be a cost-effective and effective way to employ at the national level. These findings underscore the need for the inclusion of evidence-based exercise guidelines in primary prevention policy for cardiovascular diseases.

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