Original Article

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Effect of Mat Pilates on Blood Pressure and Heart Rate Recovery in Prehypertensive College-going Students: A Randomised Controlled Trial

Physiotherapy Section

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ABSTRACT

Introduction: Prehypertension, which is believed to be a primary cardiovascular risk indicator, can develop into hypertension in case of no treatment. Exercise and lifestyle change are proposed to be the major preventive measures. In the recent past, there has been a concern over the possible cardiovascular benefits of mat Pilates, which is a mind-body practice that concentrates on breathing, core stability, and controlled movement.

Aim: To evaluate the effect of a 4-week mat Pilates programme on the Blood Pressure (BP) and Heart Rate Recovery (HRR) in prehypertensive college-going students.

Materials and Methods: This study was a parallel-group randomised control trial, 1:1 allocation ratio, conducted from July 2024 to December 2025, at Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation (MMIPR) Mullana, Ambala, Haryana, India. Total 34 prehypertensive students, aged 18 to 25 years were selected for this study, they were randomised into two groups: the Pilates group (PG) and control group (CG). Pilates group received mat Pilates along with conventional exercises and control group received only conventional exercises. The session was done for 30 minutes for four weeks. The Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Heart Rate Recovery (HRR) at one minute (HRR1) and two minutes (HRR2) were primary outcomes. The secondary outcomes were maximal heart rate (HRmax) and resting heart rate (HRrest). The statistical significance was set at p-value <0.05.

Results: Following intervention, both groups demonstrated improvement. In Pilates group, SBP dropped from 128.8±4.5 to 125.2±4.1 mmHg, while, DBP dropped from 84.6±2.3 to 83.5±1.9 mmHg, HRR1 and HRR2 also improved from 23±5.3 to 29.4±4.2 bpm and 34±5.2 to 43.2±4.5 bpm (p-value <0.05). In control group, all variables showed improvement but more in SBP 128±4.7 to 127.4±4.4 mmHg (p-value=0.004) and HRR2 (p-value=0.002). The between group analysis showed that, there were more improvement SBP (p-value <0.001), HRR1 (p-value <0.001), and HRR (p-value <0.001).

Conclusion: Mat Pilates is a more effective in improving BP and recovery of heart rate in prehypertensive students compared to conventional exercises.

Keywords: College students, Blood pressure, Heart-rate recovery, Prehypertension

INTRODUCTION

Prehypertension is a known indicator of increased cardiovascular risk and a precursor to hypertension [1]. One of the most prevalent conditions is prehypertension: it affects individuals globally; a recent study reported a startling rise prehypertension in young adults. Seventh Report of the Joint National Committee (JNC-7) sought to increase awareness of near-abnormal BP reading so that these "pre-hypertensives" might start implementing health promoting lifestyle modification to postpone the beginning of outright hypertension [2]. Prehypertension and hypertension are becoming prevalent in recent years, and they tend to be directly linked to cardiovascular and cerebrovascular disorders [2].

In accordance with "Two at least properly taken seated BP readings on each of two or more office visits," a SBP of 120 to 139 mm Hg or a DBP of 80 to 89 mm Hg is considered "prehypertension" [3]. With a annual incidence of 8-20% for trials lasting two to four years and 4-9% for long-term studies, prehypertension raises the risk of hypertension. Assuming a 50% 5-year risk, about 10 people with prehypertension would need to make major lifestyle changes and four to six would require antihypertensive medication in order to prevent an incident of hypertension [4]. By dropping BP closer to suitable range, then managing prehypertension becomes possible. Prehypertension is more prevalent in wealthier countries since BP tends to increase with age [5]. Comprehensive lifestyle changes, such as maintaining good sleep habits and appropriately increasing physical activity, are crucial because they can reduce the incidence of hypertension [6]. A powerful all-encompassing approach to controlling and preventing hypertension and cardiovascular disease is exercise. Numerous forms of exercise training, including resistance and endurance training, have been experimentally demonstrated in earlier studies to significantly lower SBP and DBP in both healthy individuals and those with hypertension [7].

The Pilates is a mind-body exercise programme that is increasingly recognised worldwide. The approach has been regarded as a rigorous, non-repetitive workout that can be tailored to each person's demands [8]. The research that has been done previously on the health outcomes of Pilates has been largely focused on quality of life, rehabilitation and general functional performance [9]. Training with the Pilates increases stimulation of the core muscles by using the centralisation technique. However, the consistent maintenance of breathing during Pilates may result in a greater adjustment of intra-abdominal pressure, which could be the reason for change in BP. It has been found that the Pilates method inhibits the Valsalva manoeuvre because these exercises require constant airflow during every stage of movement [8]. Despite the fact that Pilates has attracted a lot of attention, there is not enough data to make the conclusion that it affects prehypertensive college students' SBP and DBP as well as their HRR.

Most of the previous studies have focused on elderly population or in individual with established hypertension therefore, this study assessed the effect of mat Pilates on the cardiovascular parameters such and BP and HRR. The results of the current research could potentially provide information and direction to further larger randomised control trial. Thus, the objective of this study was to investigate the impact of a four-week mat Pilates intervention programme on BP and HRR in prehypertensive college-going students.

Null Hypothesis (H0) stated that there would be no significant Changes between BP and HRR in prehypertensive college-going students whereas, Alternate Hypothesis (H1) stated there would be significant changes between BP and HRR in prehypertensive college-going students.

MATERIALS AND METHODS

This was a parallel-group randomised control trial with an allocation ratio of 1:1, conducted at Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation (MMIPR), (MMDU), Mullana, Ambala, Haryana, India. Approval for the project was obtained from Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation (MMIPR), MM(DU), Mullana, Ambala, Haryana, India with Ethical number: IEC-3085. The trial was also registered in CTRI (CTRI/2025/07/091754). The duration of the study was conducted from July 2024 to December 2025.

Total of 38 prehypertensive college-going students were assessed for the eligibility, out of which 34 students aged 18-25 years were enrolled in this study. Four participants were excluded due to refusal to participate or not meeting inclusion criteria. All the participants provided written informed consent.

Inclusion criteria: (1) Students diagnosed with prehypertension SBP (120-139 mmHg) and DBP (80-89 mmHg); (2) Students aged between 18-25 years; (3) Both males and females; (4) Students who are not involved in any regular exercise; (5) Participants who are willing to participate in full four weeks protocol.

Exclusion criteria: (1) Students that were diagnosed with hypertension; (2) Having other health problems like diabetes or heart disease; (3) Students taking any medication that affect their heart rate or BP; (4) Smokers or who recently quit smoke; (5) Students having any injuries or conditions that prevents them exercising; (6) Students who already doing Pilates or involved in any other exercise; (7) Missed more than 25% of session.

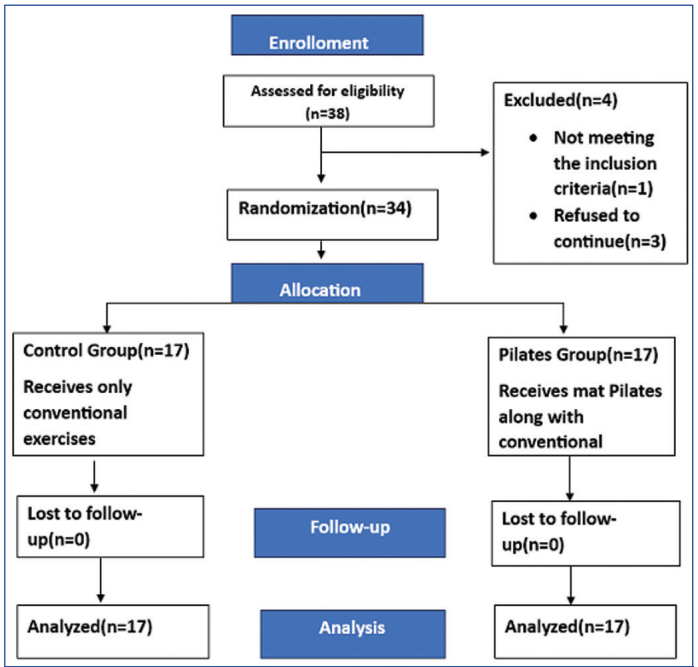
Sample size calculation: Sample size was calculated using G* power (version 3.1.9.7). A two-tailed t-test was used to calculate the difference between two independent means (two group). With a 1:1 allocation ratio between two groups, the parameters were effect size(d)=1.05 (taken from pilot study), alpha error probability(α)=0.05, and power ($1-\beta$) = 0.80. Pilot samples were included in main study. These criteria showed that each group needed 16 individuals, considering possible dropouts, for a total sample size of 32 [9]. Although the minimum required sample size was 32 participants, 34 participants (17 per group) were enrolled to further account for potential dropouts during follow-up.

Randomisation and allocation: The participants were randomly divided into two groups; Pilates group and control group through a random sequence generated by computer. The sealed opaque envelopes method was used to hide the allocation. The independent researcher created a random sequence and the investigator enrolled the participants and assigned them to groups.

Blinding: It was not possible to blind the participants and therapist because of nature of intervention. To reduce bias, however, standardised procedure was used for outcome assessment.

Outcome measures: The primary outcomes were SBP, DBP and HRR at one minute (HRR1) and at two minutes (HRR2) while, the Maximum Heart Rate (HRmax) and Resting Heart Rate (HRrest) are the secondary outcomes. BP was measured by using validated aneroid sphygmomanometer with an appropriate cuff size. Before the measurement of BP, the participants were seated and rested for about five minutes with the back support. The reading was taken from the right arm; the average of two readings was taken. The measurement was taken by the same assessor at the consistent time of the day to minimise the diurnal variation. HRR was assessed by using Queens College Step Test. The test was performed on 41.3 cm height step. The participants stepped to a metronome, females stepped at 24 steps per minute and males at 22 steps per minute, each for the duration of three minutes [9]. The safety standards were used to examine participants for any kind of contraindication to exercise prior to the test. Heart rate was measured as soon as the exercise was stopped, as well as HRR1 and HRR2 later. The difference between the peaked heart rate just after the cessation of exercise and heart rate at the corresponding recovery time point was used to measure HRR. The formula used for estimating HRmax was 220-age.

Consort flowchart is given in [Table/Fig-1]. A total of 38 participants were assessed for eligibility. Four participants were excluded due to refusal to participate or not meeting inclusion criteria. The remaining 34 participants were randomised into the Pilates group (N=17) and control group (n=17). The participants who completed the study were included in the final data analysis.



[Table/Fig-1]: CONSORT flow diagram of study.

Intervention

Mat pilates: The mat Pilates programme was performed six days/week with one day off, and each session lasted 30 minutes. The session began with 5-min warm-up, which included knee rolls, shoulder rolls, pelvic rolls, and breathing exercises and five minutes again for cool down, which included Child's pose, hamstring stretches, and supine spinal twists. The structured exercise programme included hundred preps, single leg stretch, double leg stretch, single leg circles, side-leg bicycle, side-leg kick, swan, knee push-ups, half roll-up, and shoulder bridge. Each exercise was completed in three sets using the following weekly repetition progression: each: 7 in 1st week, 10 in 2nd and 15 in 3rd, and 20 in 4th. These exercises were performed in supine, prone, side lying, kneeling and sitting position during the session, which focuses regulated breathing, pelvic stability, core activation, and proper alignment. The intensity of exercise was maintained at moderate level at 11-13 on Borg Rating of Perceived Exertion (RPE) scale [Table/Fig-2-4].

[Table/Fig-2]: Swan stretch.

[Table/Fig-3]: Double leg stretch.

[Table/Fig-4]: Knee push-ups.

Conventional exercises: The conventional exercises program given six days/week with one day off same as mat Pilates. Every session lasted 30 minutes, with two minutes of relaxation in between. Breathing, flexibility, and relaxed mobility exercises of upper and lower limb are included in it. Alternate nostril and pursed lip breathing were two breathing techniques that were practiced, twice a day for 10 minutes over the course of four week. The flexibility exercises, like hamstring, calf, neck, and cat-cow stretches, increased from three repetitions with a 30-second hold in week 1 to 5, 7, and 9 repetitions by weeks 2nd, 3rd, and 4th. Marching in place, arm circles and sit to stand were basic activities which progressed weekly and were all performed in two sets. The intensity of exercise was maintained at moderate level at 11-13 on Borg Rating of Perceived Exertion (RPE) scale. The goal for this was to boost flexibility, enhance mobility and facilitate relaxed breathing.

Education session: A healthy meal, in addition to good sleep hygiene was given to the participants. It was advised to restrict refined food, red meat, salt, and sweet drinks and to maintain a healthy diet high in fruits, vegetables, whole grains and low-fat dairy. Scheduling a regular time to fall asleep, having plenty of water throughout day, eating a steady and wholesome diet, engaging in sufficient physical activity, learning relaxation techniques before bed, making sure that the room is at the correct temperature for sleeping, and getting sufficient sun exposure during the day are all part of the sleep hygiene education.

Variables	Pilates group (Mean±SD)	Control group (Mean±SD)	p-value
Age (years)	22.4±2.2	22.6±2.3	0.06
Height (cm)	158.7±5.7	163.5±9.4	0.03
Weight (kg)	76.2±12.6	73.8±13.4	0.18
BMI (kg/m^2)	30.3±1.2	27.5±4.5	0.12

[Table/Fig-5]: Baseline demographic data of participants.
Shapiro-Wilk Test used for normality
Statistical significance at p-value <0.05

STATISTICAL ANALYSIS

The data were analysed using IBM Statistical Package for the Social Sciences (SPSS) version 26.0 software. Normality was assessed by using the Shapiro-wilk test. Normally distributed data were analysed using parametric test paired t-test for within-group, and independent sample t-test for between-group analysis. The statistical significance was set at p-value <0.05. Additionally, effect size (Cohen's d) were calculated to determine the magnitude of intervention effect. Cohen's d value was interpreted as small (0.2), medium (0.5), and large (0.8).

RESULTS

The baseline demographics like age, weight and BMI presented in [Table/Fig-5] showed that there was no statistical significant difference between age, weight, and BMI (p-value>0.05), while height showed the statistical significant (p-value <0.05) also, SBP, DBP, resting heart rate, maximum heart rate, HRR at one and two minutes (HRR1 and HRR2) did not differ statistically significantly between groups, demonstrating successful randomisation and group homogeneity.

After the four-week intervention, a within-group analysis showed that Pilates group had significantly improved. SBP dropped 128.8±4.5 mmHg to 125.2±4.1 mmHg (p-value <0.001) and DBP also dropped from 84.6±2.3 mmHg to 83.5±1.9 mmHg (p-value=0.001). Additionally, HRrest 81.2±3.7 to 78.4±3.7 bpm, p-value <0.001) and HRmax from 157±13.7 to 154.1±12.5 (p-value <0.001) showed a substantial decrease. The HRR showed improvement HRR1 increased from 23±5.3 bpm to 29.4±4.2 bpm and HRR2 from 34±5.2 bpm to 43.2±4.5 bpm, (both p-value <0.001). These results showed mat Pilates greatly enhance autonomic and cardiovascular markers [Table/Fig-6].

Variables	Pre (Mean±SD)	Post (Mean±SD)	Mean difference	t values	95% CI	p-value
SBP	128.8±4.5	125.2±4.1	3.64±2.4	6.01	2.36 to 4.93	< 0.001
DBP	84.6±2.3	83.5±1.9	1.11±1.16	3.95	0.51 to 1.71	0.001
HRrest	81.2±3.7	78.4±3.7	2.82±2.6	4.47	1.48 to 4.16	< 0.001
HRmax	157±13.7	154.1±12.5	2.88±2.2	5.19	1.70 to 4.05	<0.001
HRR1	23±5.3	29.4±4.2	-6.41±2.5	-10.1	-7.74 to -5.07	< 0.001
HRR2	34±5.2	43.2±4.5	-9.29±4.1	-9.16	-11.44 to -7.14	< 0.001

[Table/Fig-6]: Within-group comparison (Pilates Group).
Paired sample t-test used for SBP, DBP, HRrest, HRmax, HRR1, HRR2
SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HRrest: Resting Heart Rate; HRmax: Maximum Heart Rate; HRR1: Heart Rate Recovery at 1 minute; HRR2: Heart Rate Recovery at 2 minutes.
Statistical significance at p<0.05

[Table/Fig-7] shows the within-group comparison of control group. SBP drop from 128±4.7 to 127.4±4.4 mmHg (p-value=0.004) and DBP also reduced from 83.8±2 to 83.4±1.8 (p-value=0.002). Improvement was seen in HRR1 and HRR2 (p-value=0.005 and p-value=0.002, respectively). HRrest and HRmax also showed (p-value <0.05). In general, the control group showed improvement but less than that of Pilates group.

[Table/Fig-8] shows between-group comparison using the independent sample t-test, based on change scores, showed that Pilates group significantly outperformed control group in several metrics. Significant decrease was found in SBP (p-value <0.001), DBP (p-value 0.044), HRrest (p-value=0.003), HRmax (p-value=0.001), HRR1 (p-value <0.001), and HRR2 (p-value <0.001). These results indicated that Pilates had better outcomes in BP and HRR compared to conventional exercises. These findings suggested that Pilates improved BP and HRR outcomes more than conventional exercises.

Variables	Pre (Mean±SD)	Post (Mean±SD)	Mean Difference	t values	95% CI	p-value
SBP	128±4.7	127.4±4.4	0.64±0.7	3.39	0.24 to 1.05	0.004
DBP	83.8±2	83.4±1.8	0.47±0.5	3.77	0.20 to 0.73	0.002
HRrest	80.8±5.4	80.2±5.9	0.58±1.6	2.27	0.41 to 1.13	0.037
HRmax	161.1±12.3	160.5±12	0.58±0.8	2.78	0.14 to 1.03	0.013
HRR1	25±5.7	26±5	-0.94±1.1	-3.24	-1.55 to -3.26	0.005
HRR2	34.1±5.4	35.1±5.4	-1.00±1.1	-3.68	-1.57 to – 0.42	0.002

[Table/Fig-7]: Within-group comparison (control group).
Paired sample t-test used for SBP, DBP, HRrest, HRmax, HRR1, HRR2.
SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HRrest: Resting Heart Rate; HRmax: Maximum Heart Rate; HRR1: Heart Rate Recovery at 1 minute; HRR2: Heart Rate Recovery at 2 minutes.
Statistical significance at p<0.05

Variable	Pilates group (Mean±SD)	Control group (Mean±SD)	Mean difference	t values	95% CI	p-value
SBP	3.64±2.4	0.64±0.7	3.00±0.6	4.72	1.70 to 4.29	< 0.001
DBP	1.11±1.1	0.47±0.5	0.64±0.6	2.09	0.01 to 1.27	0.044
HRrest	2.82±2.6	0.58±1.6	2.23±0.6	3.27	0.84 to 3.62	0.003
HRmax	2.88±2.2	0.58±0.8	2.29±0.5	3.86	1.08 to 3.50	0.001
HRR1	-6.41±2.5	-0.94±1.1	-5.47	-7.88	-6.88 to - 4.05	< 0.001
HRR2	-9.29±4.1	-1.00±1.1	-8.29	-7.90	-10.43 to -6.15	< 0.001

[Table/Fig-8]: Between-group comparison of change Scores.
Independent sample t-test used for between-group comparison
SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HRrest: Resting Heart Rate; HRmax: Maximum Heart Rate; HRR1: Heart Rate Recovery at 1 minute; HRR2: Heart Rate Recovery at 2 minutes
Statistical significance at p<0.05.

After the intervention, both groups showed improvement in cardiovascular parameter on the whole, although the Pilates group had significantly more improvement, particularly in HRR parameters and BP, indicating better effect on autonomic activity and cardiovascular control.

DISCUSSION

This study explored the effect of mat Pilates session on BP and HRR in college prehypertensive students. It is indicated by the results that both groups showed improvement in cardiovascular parameters, but the Pilates group demonstrated a greater decrease in SBP and HRR (HRR1 and HRR2) which reflects better cardiovascular and autonomic regulation [10,11]. These results are in accordance with previous researches showing that structured exercise programme can enhance cardiovascular health and delay the development of hypertension. Similar to the findings of the present study, Martins-Meneses DT et al., and Batista JP et al., that mat Pilates are advantageous for reducing BP for a various groups of people including prehypertensive and hypertensive population [12,13].

The Pilates group showed that after the training, both SBP and DBP decreased, which was consistent with earlier research showing that Pilates has a positive effect on BP regulation. In agreement with the present study, Martins-Meneses DT et al., reported that mat Pilates training lowered clinical and ambulatory BP in hypertensive women, which may be an effect of enhanced endothelial function and decreased resistance to peripheral vascular flow [14]. Likewise, Batista JP et al., observed that a systematic Pilates programme resulted in enhanced autonomic regulation and significant drop in SBP and DBP [15]. These results are supported by previous researches that exercise based programme can lower the BPs and increase vascular compliance in people diagnosed with prehypertension and hypertension [16,17]. The observed results are may be due to improved endothelial function, betterment of autonomic function and decrease peripheral vascular resistance that linked to consistent exercise training. Together, these results corroborate the current study's findings, showing that mat Pilates effectively lower BP through comparable physiological mechanisms.

Also, the Pilates group, showed significantly greater rise in HRR (HRR1and HRR2) than the control group. HRR is a good indicator of autonomic nervous system activity, mainly parasympathetic reactivation after physical activity [18]. Faster recovery is linked to both increased cardiovascular fitness and a decrease risk of adverse cardiovascular events [19]. These findings align with the current study, where the Pilates group reported a larger improvement in their HRR and other programmed exercise training regimes have the capacity of improving cardiac autonomic control and heart rate variability [20].

The extent of change was evaluated using effect size analysis because p-values by themselves do not show the clinical significance of findings [21]. HRR1 (d=0.66) as a medium-to-large effect and HRR2 (d=1.63) demonstrated extremely large effect, confirming that the intervention had a clinically significant impact, while systolic BP (d=0.52) exhibited a medium effect size. DBP and resting heart rate showed very small effect, whereas maximum heart rate showed only medium effect. These results imply that mat Pilates has major clinical relevance in enhancing cardiovascular and autonomic function in addition to producing statistically significant benefits.

The cause of these changes may be physiological, such as increased activation of the parasympathetic system, suppression of sympathetic activity, increased availability of nitric oxide, and improved endothelial function [22]. According to previous studies, exercise therapies can enhance the nervous system, reduce oxidative stress, and improve endothelial function, all of which lead to better cardiovascular health.

Between-group analysis showed that the mat Pilates intervention was effective in improving all the variables. There was a significant reduction was found in SBP (p-value <0.001), DBP (p-value=0.044), resting heart rate (p-value=0.003), maximum heart rate (p-value=0.001), HRR1 (p-value <0.001) and HRR2 (p-value <0.001). These findings indicate that mat Pilates is effective in improving cardiovascular parameters. Also, it is a safe, feasible, and effective non-pharmacological intervention for early cardiovascular risk management in prehypertensive people from a clinical perspective. It can be used in preventive rehabilitation programme for bettering autonomic and cardiovascular health. Prevention of development of prehypertension to the hypertension requires lifestyle changes, particularly organised exercise programme [22]. Consequently, incorporating Pilates into the physical activities can assist the youth in minimising cardiovascular issues. Future research should focus on different demographics, larger sample size and longer intervention duration. To confirm these findings, larger sample size, longer intervention time, and a wider range of population could be included in future studies. The integration of objective biochemical and autonomic markers such as heart rate variability could provide more information.

Limitation(s)

There are some limitations that this study has which must be taken into account when interpreting the finding of the study. First, the sample size was not that large, which could restrict the generalisation of the findings. Second, the intervention was limited (four weeks), and the long-term impacts of mat Pilates on cardiovascular parameters could not be identified. Third, only young prehypertensive college students were included in the study population, which make it difficult to apply the findings to other groups or clinical populations. Fourth, participants could not be blinded because of the characteristics of the intervention, which could have brought about the performance bias. Fifth, there was no strict control over the physical activity of the participants and the factors of their lifestyles outside the intervention, which might affect the results. Sixth, a follow-up was not performed in the long run in order to evaluate the sustainability of the results.

CONCLUSION(S)

This study showed that prehypertensive college students' cardiovascular parameters can be significantly improved by a four-week mat Pilates programme. Even though both groups improved, the Pilates group demonstrated more SBP reduction and higher improvements in HRR as compared to regular exercises. There was no significant difference in between groups in DBP. This result indicates that mat Pilates can be a safe, feasible, and effective non-pharmacological intervention to reduce early cardiovascular risk in prehypertensive persons. The introduction of mat Pilates in regular physical exercise routine could be beneficial in enhancing cardiovascular control. However, in order to ascertain long-term effects on cardiovascular parameters, future research with larger sample size and longer follow-up investigations could support these findings.

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