Effects of a 4-Week Core Stability Training Program on Heart Rate, Oxygen Saturation, Blood Pressure, and Estimated Oxygen Consumption in Prehypertensive Adults: A Quasi-Experimental Study

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Abstract: ***Background of the study**: Prehypertension is associated with increased cardiovascular risk, and exercise-based interventions may help improve cardiovascular and respiratory function. **Aim**: To study the effect of core stability exercise on recovery heart rate, oxygen consumption, and breathing patterns in prehypertensive patients. **Objectives**: To evaluate the effects of a 4-week core stability training program on recovery heart rate, oxygen saturation, estimated oxygen consumption, breathing pattern, and blood pressure among prehypertensive adults. **Methodology**: A quasi-experimental pre-post study was conducted among 37 prehypertensive adults aged 25 to 50 years. Participants underwent core stability training with diaphragmatic breathing three times weekly for 4 weeks. Outcomes included heart rate, oxygen saturation, blood pressure, estimated oxygen consumption derived from heart rate, and breathing pattern assessment. Pre-post comparisons were statistically analysed. **Results and Conclusion**: Significant reductions were observed in heart rate and blood pressure, with improvement in oxygen saturation following intervention physiotherapy intervention. Recovery heart rate was defined as the heart rate measured one minute after completion of exercise using a pulse oximeter. Oxygen consumption was estimated using the regression equation VO2=0.20\times HR-11. Breathing pattern was assessed by measuring respiratory rate (breaths/minute) before and after the intervention.*

Keywords: Prehypertension; Core Stability Training; Heart Rate Recovery; Blood Pressure; Oxygen Saturation; Exercise Therapy; Cardiovascular Rehabilitation

1. Introduction

Exercise induces a wide range of physiological responses involving the cardiovascular, respiratory, and musculoskeletal systems.[1] One of the most immediate and measurable responses to exercise is an increase in heart rate (HR), which begins even before the onset of physical activity due to central command from the cerebral cortex.[1] This anticipatory response reduces vagal tone and prepares the cardiovascular system for increased metabolic demands. During exercise, heart rate increases primarily due to vagal withdrawal, with sympathetic activation contributing further, especially during severe or prolonged muscular activity.[1]

Several factors contribute to the exercise-induced rise in heart rate, including afferent impulses from muscle proprioceptors, increased carbon dioxide tension acting on medullary centres, elevated body temperature influencing cardiac centre's via the hypothalamus, and increased circulating catecholamines.[1] Post-exercise heart rate recovery (HRR), particularly within the first minute after cessation of exercise, reflects autonomic nervous system function and cardiovascular fitness.[6,13,14] A one-minute HRR of 15–25 beats per minute is considered normal in healthy individuals, though significant inter-individual variation exists.[1]

Oxygen consumption (VO_2) also increases substantially during exercise to meet the heightened metabolic requirements of active skeletal muscles.[2,3] Exercise-induced vasodilatation enhances blood flow to working muscles, facilitating increased oxygen delivery and utilization.[1] The amount of oxygen consumed by the muscles is directly proportional to its availability in the blood, making VO_2 a key indicator of cardiorespiratory efficiency.[11,12,15]

Breathing patterns are closely linked to both exercise performance and recovery. Proper breathing is particularly important during core stability exercises, as the respiratory muscles, especially the diaphragm and deep abdominal muscles, play a dual role in respiration and postural control.[4] Core exercises have been shown to alter breathing patterns, often promoting shallower breathing compared to deep breathing, due to sustained activation of stabilizing muscles.[4]

Core stability training primarily aims to improve balance, posture, and trunk control, reduce the risk of injury, and alleviate low back pain by strengthening the muscles of the lumbopelvic region.[7,8,9,10,17] Importantly, core muscles, including the diaphragm and deep abdominal stabilizers, also contribute to breathing efficiency and cardiac autonomic regulation.[4,18,19,20] Despite these interconnected roles, limited research has examined the effects of core stability training on post-exercise heart rate recovery, oxygen consumption, and breathing patterns, particularly in individuals with prehypertension.[18,19]

Prehypertension is associated with altered autonomic control and an increased risk of developing hypertension and cardiovascular disease. [21,22,23,24] Identifying effective, non -pharmacological exercise interventions that improve cardiovascular efficiency and autonomic regulation is therefore of clinical importance. Core stability training may offer such benefits by influencing cardiorespiratory responses and enhancing recovery mechanisms following exercise.

2. Methodology

Study design: Quasi experimental study.

Study area: Health check-up OPD, Narayana Hrudayalaya Health City, Bangalore.

Study Duration: 3 months

Study population: Subjects with prehypertension are selected according to the criteria of the study from the department of health checkup OPD.

Sampling: Matched pair nonrandom sampling.

Sample size (with justification):

$$n \geq \frac{\left(Z_{\frac{1-\alpha}{2}}+Z_{1-\beta}\right)^2\left(\frac{\sigma_1^2+\sigma_2^2}{r}\right)}{(\mu_1-\mu_2)^2}$$

Total sample size = 37

Ethical considerations/number: NHH/AEC-CL-2026-1564

Eligibility Criteria and Participants recruitment procedure:

Inclusion criteria:
- Age 25–50 years.
- Prehypertensive status (SBP 120–139 mmHg, DBP 80–89 mmHg)
- Sedentary or moderately active individuals.

Exclusion criteria:
- Hypertension (≥140/90 mmHg) or diagnosed cardiovascular diseases.
- Individuals on antihypertensive medications.
- Respiratory disorders, diabetes, or recent musculoskeletal

Procedure:
Subjects who fulfilled the eligibility criteria and were willing to participate in the study were recruited for the study. Using non- random sampling the subjects are selected

Informed Consent was obtained from the participant before the onset of the study

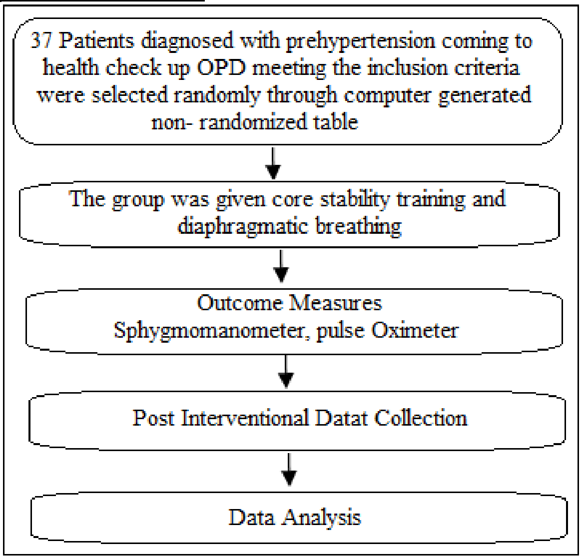
Techniques applied in the study were of standard of care.

Blood pressure was assessed using sphygmomanometer, oxygen saturation and heart rate was measured using pulse oximeter, vo2 using regression equation VO2=0.20\times HR-11 and breathing pattern manually assessed for all subjects before the procedure.

Each session began with a warm-up of 5–10 minutes consisting of light cardio and dynamic stretching, followed by core exercises including diaphragmatic breathing for 5 minutes, Swiss ball plank for 3 sets of 30–45 seconds, Swiss ball Russian twists for 3 sets of 15 repetitions, Bird-Dog exercise for 3 sets of 10 repetitions on each side, and Swiss ball abdominal rollout for 3 sets of 10 repetitions. The session concluded with a 5-minute cool-down consisting of static stretching and breathing exercises.

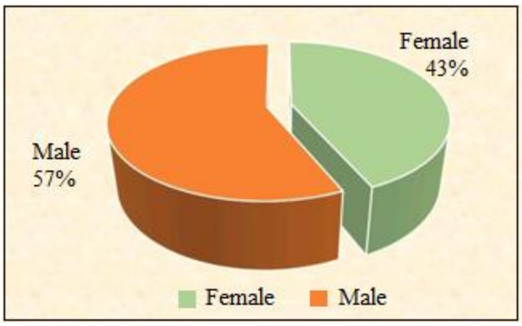
After 4 weeks of intervention the post-intervention data were collected.

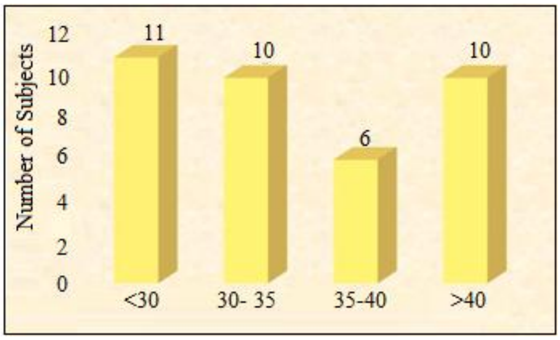
Flow of Participants:



Data Analysis:
Statistical analysis was performed using SPSS Version 27. Pre- and post-test comparisons were analyzed using the Paired t-test. Correlation was analyzed using Pearson's correlation test. A p-value <0.05 was considered significant.

Descriptive/ Demographic: Graph 1 & 2





The graph represents the demographic distribution of participants based on gender and age. Among the total participants, 21 were males and 16 were females, showing a slightly higher proportion of males. Age-wise, the highest number of participants were below 30 years (11 participants), followed by the 30–35 years and above 40 years age groups (10 participants each), while the least were in the 35–40 years age group (6 participants). The distribution reflects inclusion of participants across varied adult age groups.

Descriptive Statistics of Demographic and Physiological Variable

		AGE	HR PRE	HR POST	SpO2 PRE	SpO2 POST	SBP PRE	DBP PRE	SBP POST	DBP POST
N	Valid	37	37	37	37	37	37	37	37	37
Mean		35.514	85.135	80.486	96.811	98.162	129.081	84.784	122.703	80.919
Median		34.000	85.000	80.000	97.000	98.000	129.000	85.000	123.000	81.000
Std. Deviation		7.441	3.351	3.517	.877	.958	5.449	2.347	5.359	2.499
Range		24.000	12.000	12.000	3.000	4.000	19.000	9.000	19.000	10.000
Minimum		25.000	80.000	74.000	95.000	96.000	120.000	80.000	114.000	76.000
Maximum		49.000	92.000	86.000	98.000	100.000	139.000	89.000	133.000	86.000

Descriptive Statistics of Pre-Test and Post-Test Variables

		Statistic
HR PRE	Mean	85.14
	Median	85.00
	Std. Deviation	3.351
	Interquartile Range	6
SpO2 PRE	Mean	96.81
	Median	97.00
	Std. Deviation	.877
	Interquartile Range	1
SBP PRE	Mean	129.0811
	Median	129.0000
	Std. Deviation	5.44864
	Interquartile Range	10.00
DBP PRE	Mean	84.78
	Median	85.00
	Std. Deviation	2.347
	Interquartile Range	4

		Statistic
HR POST	Mean	80.486
	Median	80.000
	Std. Deviation	3.517
	Interquartile Range	7.000
SpO2 POST	Mean	98.162
	Median	98.000
	Std. Deviation	.958
	Interquartile Range	1.000
SBP POST	Mean	122.703
	Median	123.000
	Std. Deviation	5.359
	Interquartile Range	9.000
DBP POST	Mean	80.919
	Median	81.000
	Std. Deviation	2.499
	Interquartile Range	4.000

The table shows the descriptive statistics of the pre-test and post-test variables. Before intervention, the mean heart rate was 85.14 bpm, mean oxygen saturation was 96.81%, mean systolic blood pressure was 129.08 mmHg, and mean diastolic blood pressure was 84.78 mmHg. Following the intervention, the mean heart rate decreased to 80.49 bpm, while oxygen saturation improved to 98.16%. The mean systolic blood pressure reduced to 122.70 mmHg and the mean diastolic blood pressure decreased to 80.92 mmHg, indicating improvement in cardiovascular and respiratory parameters after the core stability training program.

Comparison of Pre and Post Heart Rate:

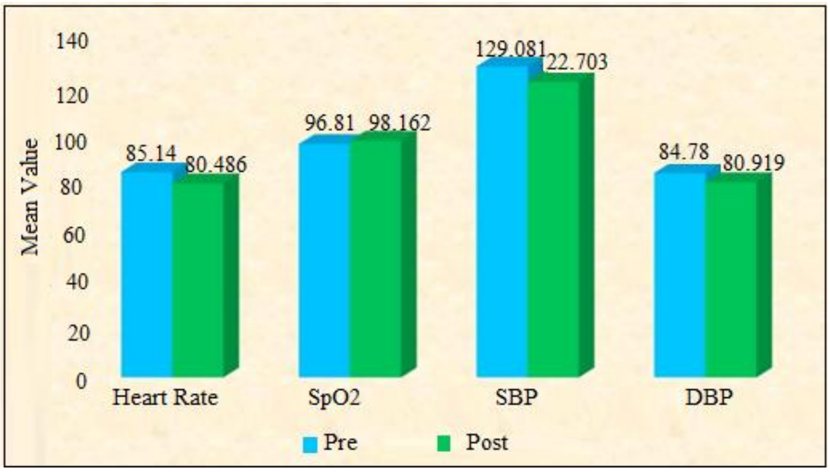
	Paired Difference			
	Mean	Std. Deviation	Z	p
HR PRE- HR Post	4.649	2.519	5.270	<0.001 vhs

shows the comparison between pre and post heart rate using the Wilcoxon Signed Rank Test. The mean reduction in heart rate was 4.649 bpm. The obtained p-value was less than 0.001, indicating a statistically significant reduction in heart rate after intervention.

Comparison of Pre and Post SPO2

	Mean	Std. Deviation	Z	p
SpO2 PRE- SpO2 Post	-1.351	.588	5.429	<0.001 vhs

The table presents the comparison of pre- and post-intervention oxygen saturation (SpO_2) levels within the group using the Paired t-test. There was a statistically highly significant improvement in SpO_2 levels after the intervention ($p < 0.001$).



Graph 3: Comparison of Pre and Post data

The graph compares the pre-intervention and post-intervention values of physiological parameters HR, SpO_2 SBP and DBP. After the intervention, heart rate decreased from 85.14 to 80.486 beats/min, indicating improved cardiovascular response. SpO_2 increased from 96.81% to 98.162%, suggesting better oxygenation. Similarly, systolic blood pressure reduced from 129.081 mmHg to 122.703 mmHg and diastolic blood pressure decreased from 84.78 mmHg to 80.919 mmHg. Overall, the graph demonstrates positive physiological improvements following the intervention.

3. Results

This quasi-experimental study was conducted to evaluate the effects of core stability training on heart rate, oxygen saturation, blood pressure, oxygen consumption, and breathing patterns in prehypertensive individuals. A total of 37 participants underwent a 4-week structured core stability training program including diaphragmatic breathing, Swiss ball exercises, bird-dog exercises, abdominal rollouts, and cool-down exercises. Among the participants, 21 were males and 16 were females, with a mean age of 35.51 years.

Post-intervention analysis showed a statistically highly significant reduction in heart rate from 85.14 bpm to 80.49 bpm ($p < 0.001$). Oxygen saturation significantly improved from 96.81% to 98.16% ($p < 0.001$). Systolic blood pressure reduced from 129.08 mmHg to 122.70 mmHg, while diastolic blood pressure decreased from 84.78 mmHg to 80.92 mmHg, both showing statistically highly significant improvement ($p < 0.001$). Estimated oxygen consumption calculated using the regression equation

VO2=0.20\times HR-11

also showed a reduction following intervention, indicating improved cardiovascular efficiency. Additionally, participants demonstrated improved diaphragmatic breathing patterns and better breathing control after the training program. Overall, the findings suggest that core stability training positively influences cardiovascular and respiratory parameters in prehypertensive individuals

4. Discussion

The findings of the present study are supported by the study conducted by Gayathri Balakavi et al., which examined the cardiovascular response to core stability exercises in healthy individuals. Their study reported significant increases in heart rate and systolic blood pressure immediately after exercise performance due to acute cardiovascular stress. In contrast, the present study evaluated the long-term effects of a 4-week core stability training program in prehypertensive individuals and demonstrated significant reductions in heart rate and blood pressure, indicating improved cardiovascular adaptation and recovery. Additionally, the previous study was limited to healthy adults aged 18–25 years and assessed only heart rate, systolic blood pressure, and rate pressure product. The present study included additional parameters such as oxygen saturation, oxygen consumption, and breathing pattern, providing a more comprehensive assessment of cardiovascular and respiratory efficiency.[12]

The present study also demonstrated better overall physiological improvement compared to the walking-based intervention study conducted by Chaitali S. Vikhe et al., which evaluated the effects of a 14-day walking regimen in prehypertensive young adults. Although their study showed improvements in blood pressure and cardiovascular fitness, the present study demonstrated additional improvements in oxygen saturation, breathing pattern, and oxygen consumption following a structured 4-week core stability training program. Furthermore, the previous study had a shorter intervention duration and focused mainly on walking activity, whereas the present study incorporated multiple therapeutic core exercises and diaphragmatic breathing techniques, which may explain the superior improvements observed in cardiovascular recovery and respiratory efficiency. Therefore, the findings suggest that core stability training is an effective non-pharmacological intervention for improving cardiovascular and respiratory health in prehypertensive individuals.[13]

5. Conclusion

This quasi-experimental study suggests that a 4-week *Core Stability Training* program was associated with improvements in *recovery heart rate, oxygen saturation, oxygen consumption, breathing pattern,* and *blood pressure* in *prehypertensive individuals*. The intervention demonstrated positive effects on *cardiovascular efficiency, respiratory control,* and *autonomic recovery* following exercise. *Core Stability Training* may be considered a simple, cost-effective, non-invasive, and easily applicable exercise-based intervention that can be incorporated along with *conventional physiotherapy* and *lifestyle modification programs* for individuals with *prehypertension*. However, due to the absence of a control group, relatively small sample size, and indirect estimation of certain outcomes, the findings should be interpreted with caution. Further large-scale controlled studies are recommended to confirm the effectiveness of the intervention.

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