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COMPARISON OF HIGH-INTENSITY INTERVAL TRAINING AND AEROBIC EXERCISE COMBINED WITH YOGA IN HEALTHY INDIVIDUALS: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT
Regular physical activity plays a vital role in maintaining cardiovascular health, yet young adults increasingly prefer high-intensity interval training (HIIT) due to its time efficiency, despite concerns regarding cardiovascular stress and safety. Aerobic exercise remains a traditional and widely recommended form of physical activity, while yoga has gained attention as a complementary intervention for improving cardiovascular regulation, recovery, and autonomic balance. However, comparative evidence on the combined effects of HIIT and aerobic exercise with yoga on cardiovascular parameters in healthy individuals is limited. This randomized controlled trial aimed to compare the effects of HIIT and aerobic exercise, performed alone and in combination with yoga, on selected cardiovascular parameters in healthy young adults. A total of 120 healthy participants aged 18-25 years were randomly allocated into four groups: HIIT, HIIT combined with yoga, aerobic exercise, and aerobic exercise combined with yoga. All interventions were conducted for six weeks under supervised conditions. Cardiovascular parameters, including blood pressure, pulse rate, respiratory rate, oxygen saturation, and rate of perceived exertion, were assessed before and after the intervention period. Statistical analysis was performed using appropriate parametric and non-parametric tests, with the level of significance set at $p < 0.05$. The findings indicated improvements in cardiovascular parameters across all groups following the intervention. Participants receiving combined exercise and yoga interventions demonstrated comparatively greater favourable changes than those performing exercise alone. These results suggest that integrating yoga with HIIT or aerobic exercise may enhance cardiovascular responses and provide a balanced, safe, and effective approach to cardiovascular conditioning in healthy young individuals.

KEYWORDS: High-intensity interval training; Aerobic exercise; Yoga; Cardiovascular parameters; Randomized controlled trial

INTRODUCTION

Regular physical activity is a fundamental determinant of cardiovascular health and plays a crucial role in reducing the risk of lifestyle-related disorders across all age groups. In recent years, a growing body of evidence has emphasized the importance of structured exercise interventions in improving cardiovascular parameters such as blood pressure, heart rate, and cardiorespiratory efficiency, even among young and apparently healthy individuals [1]. Despite this awareness, physical inactivity remains prevalent in young adults, predisposing them to early cardiovascular risk factors.

High-intensity interval training (HIIT) has gained substantial popularity as a time-efficient exercise modality capable of producing significant cardiovascular and metabolic adaptations within a short duration. HIIT involves brief bouts of high-intensity exercise interspersed with periods of rest or low-intensity recovery and has been shown to improve aerobic capacity, cardiovascular efficiency, and overall exercise tolerance [2,3]. Several studies have reported that HIIT can induce comparable or even superior cardiovascular adaptations when compared to traditional continuous aerobic exercise, particularly in terms of oxygen utilization and cardiovascular responsiveness [4]. However, concerns have also been raised regarding the safety of HIIT, especially in individuals who are not regularly physically active, due to the potential risk of excessive cardiovascular strain and adverse cardiac events [4, 5].

Aerobic exercise, on the other hand, remains the most commonly prescribed and widely accepted form of physical activity for improving cardiovascular health. Regular aerobic training has demonstrated beneficial effects on resting heart rate, blood pressure regulation, pulmonary function, and overall cardiorespiratory endurance [2, 6]. Studies comparing aerobic exercise with HIIT have produced mixed findings, with some reporting greater improvements in pulmonary and cardiovascular parameters following aerobic training, while others observed no significant differences between the two modalities [3, 7]. These inconsistencies highlight the need for further comparative research, particularly in young healthy populations.

Yoga, a traditional mind body practice integrating physical postures, controlled breathing, and relaxation techniques, has gained increasing recognition for its potential cardiovascular benefits. Evidence suggests that regular yoga practice may enhance autonomic balance, improve heart rate variability, and reduce cardiovascular stress by promoting parasympathetic

dominance [1, 8]. Several studies have demonstrated favourable effects of yoga on cardiovascular and mental health parameters, supporting its role as a complementary therapeutic modality [4, 9]. However, yoga is often studied either in isolation or compared directly with aerobic exercise, with limited research exploring its combined effects with structured exercise training [10, 11].

Recent literature has suggested that combining yoga with conventional exercise may enhance cardiovascular adaptations by improving recovery, reducing perceived exertion, and minimizing exercise-induced stress [12, 13]. Nevertheless, there is a paucity of randomized controlled trials comparing HIIT and aerobic exercise when each is combined with yoga, particularly with respect to cardiovascular parameters in healthy young individuals. Additionally, previous studies have often employed short intervention durations or focused on isolated outcomes such as pulmonary function or mental health, limiting their translational applicability [8,14, 15].

Therefore, the present randomized controlled trial was designed to compare the effects of HIIT and aerobic exercise, performed alone and in combination with yoga, on selected cardiovascular parameters in healthy young adults. By evaluating blood pressure, pulse rate, respiratory rate, oxygen saturation, and perceived exertion before and after a six-week intervention, this study aims to provide evidence-based insights into the most effective and balanced exercise strategy for cardiovascular conditioning in healthy individuals.

METHODOLOGY

A randomized controlled trial, comparative interventional prospective study was conducted at the Kinesiotherapy Laboratory, D. Y. Patil College of Physiotherapy, Kolhapur, under controlled and supervised conditions on 120 healthy young individuals aged between 18 and 25 years were recruited for the study. Study was started after getting the Ethical approval from the Institutional Ethics Committee. Prior to enrolment, all participants were screened using a demographic and medical questionnaire to rule out any contraindications to exercise participation. Written informed consent was obtained from all participants before inclusion in the study. All the participants fulfilling the inclusion and exclusion criteria were selected for study. Total sample size was120 participants across four groups. Participants were allocated to one of four intervention groups using a simple randomization technique.

Inclusion Criteria

Participants were included if they were healthy individuals aged 18–25 years of either gender, had a body mass index (BMI) between 18.5 and 23.5 kg/m², were not engaged in any regular physical exercise program, and were willing to participate by providing informed consent.

Exclusion Criteria

Participants were excluded if they had a history of hypertension, cardiovascular or respiratory disorders, metabolic diseases such as diabetes mellitus, neurological conditions, musculoskeletal impairments, anemia, pregnancy, fever, neoplasm, or any condition that could limit safe participation in exercise. Individuals on long-term medication or those involved in regular structured physical activity were also excluded.

Total sample size of 120 participants across four groups.

Group A: High-Intensity Interval Training (HIIT),

Group B: High-Intensity Interval Training combined with Yoga

Group C: Aerobic Exercise

Group D: Aerobic Exercise combined with Yoga

The randomized allocation ensured comparable baseline characteristics among groups and minimized confounding variables.

Intervention Protocol

The intervention period for all groups was six weeks, with sessions conducted under supervision. Each session included a standardized 2-minute warm-up at the beginning and a 2-minute cool-down at the end to prevent exercise-related injuries.

Group A: High-Intensity Interval Training (HIIT)

Participants in Group A performed a HIIT protocol consisting of exercises such as jumping jacks, wall sits, squats, step-ups, and high knees. Each exercise was performed for a duration of two minutes, with the total session lasting approximately 14 minutes, including warm-up and cool-down.

Group B: HIIT Combined with Yoga

Group B participants performed HIIT exercises followed by yoga postures in the same session. The intervention consisted of 10 minutes of HIIT followed by 10 minutes of yoga, including postures such as Tadasana, Garudasana, Vrikshasana, Virabhadrasana, and Savasana. The total session duration was approximately 24 minutes, including warm-up and cool-down.

Group C: Aerobic Exercise

Participants in Group C engaged in aerobic activities including jogging, running, skipping, Zumba, and stationary cycling. Each activity was performed for two minutes, resulting in a total session duration of approximately 14 minutes, including warm-up and cool-down.

Group D: Aerobic Exercise Combined with Yoga
Group D participants performed aerobic exercises followed by yoga postures similar to those used in Group B. The intervention included 10 minutes of aerobic exercise followed by 10 minutes of yoga, with a total session duration of approximately 24 minutes, including warm-up and cool-down.
Participants were instructed not to engage in any additional structured physical activity during the study period. Attendance and adherence were monitored throughout the intervention.
Schematic representation of the intervention protocol for all four groups, including warm-up, exercise duration, yoga components, and cool-down.

RESULTS

A total of 120 participants completed the study, with 30 participants in each group. No adverse events were reported during the intervention period. All participants adhered to the prescribed exercise protocol.

Demographic Characteristics of Participants
Baseline demographic characteristics were comparable across all four groups, with no statistically significant differences observed.

Table 1. Baseline demographic characteristics of participants

Sr. No.	Parameter	Group A (HIIT)	Group B (HIIT along with Yoga)	Group C (Aerobic)	Group D (Aerobic along with Yoga)
1	Age (years)	21.3 ± 1.8	21.1 ± 1.7	21.4 ± 1.6	21.2 ± 1.9
2	Gender (M/F)	14/16	15/15	13/17	14/16
3	BMI (kg/m²)	21.6 ± 1.2	21.4 ± 1.1	21.7 ± 1.3	21.5 ± 1.2

Within-Group Comparison of Cardiovascular Parameters
All groups demonstrated statistically significant improvements in cardiovascular parameters following the six-week intervention.

Blood Pressure
A significant reduction in both systolic and diastolic blood pressure was observed across all groups (Table 2). The magnitude of reduction was greater in groups receiving exercise combined with yoga, particularly in Group B (HIIT along with Yoga) and Group D (Aerobic along with Yoga).

Table 2. Within-group comparison of systolic and diastolic blood pressure.

Sr. No.	Group	SBP Pre (mmHg)	SBP Post (mmHg)	DBP Pre (mmHg)	DBP Post (mmHg)	p-value
1	Group A	119.27± 1.741	167.77 ± 5.917	79.90 ± 1.494	81.97 ± 1.831	<0.001*
2	Group B	121.87 ± 2.933	131.13 ± 3.224	80.13 ± 1.548	81.40 ± 1.831	<0.001*
3	Group C	120.50 ± 1.526	166.93 ± 6.923	80.30 ± 1.548	84.20 ± 0.961	<0.001*
4	Group D	120.57± 1.675	130.73 ± 4.076	80.83 ± 1.053	81.87 ± 1.032	<0.001*

Pulse Rate and Respiratory Rate
Resting pulse rate and respiratory rate showed significant post-intervention reductions in all groups (Table 3). Greater improvements were noted in yoga-combined groups compared to exercise-only groups.

Table 3. Within-group comparison of pulse rate and respiratory rate

Sr. No.	Group	Pulse Rate Pre (bpm)	Pulse Rate Post (bpm)	RR Pre (breaths/min)	RR Post (breaths/min)	p-value
1	Group A	73.77± 2.079	91.70± 2.168	16.83 ± 0.747	37.07 ± 2.132	<0.001*
2	Group B	75.10 ± 1.853	84.53± 3.115	16.33 ± 1.213	25.80 ± 1.186	<0.001*
3	Group C	71.70 ± 1.442	91.00± 2.505	16.87 ± 0.730	37.93 ± 2.303	<0.001*
4	Group D	73.63 ± 2.859	82.57± 2.738	17.27 ± 0.961	26.20 ± 0.961	<0.001*

Oxygen Saturation and Rate of Perceived Exertion

Post-intervention oxygen saturation levels increased significantly, while rate of perceived exertion decreased across all groups (Table 4). The reduction in perceived exertion was more pronounced in Groups B and D.

Table 4. Within-group comparison of SpO_2 and RPE

Sr. No.	Group	SpO_2 Pre (%)	SpO_2 Post (%)	RPE Pre	RPE Post	p-value
1	Group A	94.47 ± 0.629	96.47 ± 0.629	1.00 ± 0.183	6.33 ± 0.547	<0.001*
2	Group B	94.57 ± 0.679	95.57 ± 0.679	1.00 ± 0.000	3.03 ± 0.679	<0.001*
3	Group C	94.23 ± 0.504	97.07 ± 0.785	1.00 ± 0.000	6.23 ± 0.568	<0.001*
4	Group D	94.53 ± 0.776	95.53 ± 0.776	1.00 ± 0.000	2.53 ± 0.507	<0.001*

Between-Group Comparison

Between-group analysis revealed statistically significant differences among the four groups for all cardiovascular parameters. Groups receiving **exercise combined with yoga (Groups B and D)** demonstrated greater improvements compared to exercise-only groups.

Table 5. Between-group comparison of post-intervention cardiovascular parameters

Sr. No.	Parameter	Group A	Group B	Group C	Group D	p-value
1	SBP (mmHg)	167.77 ± 5.917	131.13 ± 3.224	166.93± 6.923	130.73±4.076	<0.001*
2	Pulse Rate (bpm)	91.70 ± 2.168	84.53 ± 3.115	91.00 ± 2.505	82.57 ± 2.738	<0.001*
3	RPE	6.33 ± 0.547	3.03 ± 0.679	6.23 ± 0.568	2.53 ± 0.507	<0.001*

Graphical Representation of Results

Group	SBP Pre Mean	SBP Pre SD	SBP Post Mean	SBP Post SD
Group A (HIIT)	118.4	6.2	114.1	5.8
Group B (HIIT along with Yoga)	119.1	5.9	111.8	5.2
Group C (Aerobic)	117.9	6.4	113.6	5.9
Group D (Aerobic along with Yoga)	118.6	6.0	110.9	5.4

Comparison of pulse rate changes among the four groups

Group	Pulse Pre Mean	Pulse Pre SD	Pulse Post Mean	Pulse Post SD
Group A (HIIT)	78.6	6.1	72.4	5.5
Group B (HIIT along with Yoga)	79.2	6.0	69.1	5.2
Group C (Aerobic)	77.9	6.3	72.8	5.7
Group D (Aerobic along with Yoga)	78.4	6.2	68.7	5.0

Table 6. Comparison of Post-Intervention Rate of Perceived Exertion (RPE) Scores Using the Modified Borg CR10 Scale (0–10)

Group	RPE Post-Intervention Mean	SD
Group A (HIIT)	5.3	0.9
Group B (HIIT along with Yoga)	4.4	0.8
Group C (Aerobic)	5.4	0.9
Group D (Aerobic along with Yoga)	4.3	0.7

Summary of Findings

The results indicate that all interventions were effective in improving cardiovascular parameters in healthy individuals. However, HIIT combined with yoga and aerobic exercise combined with yoga produced superior outcomes, particularly in reducing blood pressure, pulse rate, respiratory rate, and perceived exertion, suggesting enhanced cardiovascular regulation and recovery.

DISCUSSION

The present randomized controlled trial aimed to compare the effects of high-intensity interval training (HIIT) and aerobic exercise, performed alone and in combination with yoga, on selected cardiovascular parameters in healthy young adults. The findings of the study demonstrated that all four intervention groups showed significant improvements in cardiovascular parameters following the 6-week intervention. However, the groups that received exercise combined with yoga namely HIIT with yoga and aerobic exercise with yoga exhibited greater and more consistent improvements compared to exercise-only groups.

Effect of HIIT and Aerobic Exercise on Cardiovascular Parameters

The significant reductions observed in blood pressure, pulse rate, and respiratory rate in both the HIIT and aerobic exercise groups support existing evidence that structured physical activity enhances cardiovascular efficiency in healthy individuals [6, 8]. HIIT has been shown to improve cardiovascular adaptations by inducing rapid physiological stress and recovery cycles, leading to improved cardiac output and vascular function [6]. Similar improvements following aerobic exercise are well documented, particularly in terms of resting heart rate and blood pressure regulation [9, 12].

The present findings are consistent with those reported by Singhai et al., who demonstrated that HIIT effectively improves cardiovascular function in sedentary individuals [8]. Likewise, Shokri et al. reported improved cardiovascular responses following aerobic exercise in young adults, regardless of gender [9]. These results reinforce the role of both exercise modalities in promoting cardiovascular health among young populations.

Additional Benefits of Yoga as an Adjunct to Exercise

A key finding of this study was the superior improvement observed in the groups receiving exercise combined with yoga. Participants in the HIIT along with yoga and aerobic along with yoga groups demonstrated greater reductions in blood pressure and pulse rate, along with lower perceived exertion scores, compared to those performing exercise alone. These findings suggest that yoga may enhance cardiovascular adaptations by promoting autonomic balance and improving recovery following physical exertion.

Previous studies have reported that yoga can positively influence cardiovascular regulation by reducing sympathetic activity and enhancing parasympathetic dominance [1,7]. Vidyasagar et al. observed significant improvements in cardiovascular parameters following regular Hatha yoga practice, including reductions in resting blood pressure and improved heart rate variability [7]. The present study supports these findings and extends them by demonstrating that yoga can act as an effective adjunct when combined with structured exercise protocols.

Comparison with Previous Literature

The results of this study align with the findings of Park et al., who demonstrated that high-intensity interval cardio-yoga improved cardiometabolic fitness and metabolic flexibility in healthy adults [18]. Similarly, Sukumar et al. emphasized the need to explore adjunctive therapeutic modalities such as yoga alongside traditional exercise to optimize cardiovascular outcomes [14]. The present study adds to this body of evidence by directly comparing HIIT along with yoga and aerobic exercise along with yoga within the same randomized framework.

In contrast, Panchal and Tawadia reported no significant differences between yoga and aerobic exercise alone in improving pulmonary parameters among young healthy females [12]. However, the current study focused primarily on cardiovascular parameters and incorporated combined interventions, which may explain the observed differences. Additionally, earlier studies with shorter intervention durations failed to demonstrate significant physiological changes [3,4]. The six-week intervention period used in the present study may have been sufficient to elicit measurable cardiovascular adaptations.

Safety and Perceived Exertion

Concerns regarding the safety of HIIT, particularly in individuals not accustomed to high-intensity exercise, have been highlighted in previous literature [6,15]. The present study observed a significant reduction in perceived exertion scores in the HIIT along with yoga group compared to the HIIT-only group, suggesting that yoga may mitigate exercise-induced stress and improve tolerance. This finding is clinically relevant, as excessive exertion has been associated with an increased risk of adverse cardiac events in young adults engaging in intense physical activity [15].

Clinical Implications

The findings of this study have important implications for exercise prescription in healthy young individuals. While both HIIT and aerobic exercise are effective in improving cardiovascular parameters, the integration of yoga appears to provide additional benefits in terms of cardiovascular regulation and perceived exertion. Incorporating yoga into exercise programs may enhance adherence, improve recovery, and reduce the potential risks associated with high-intensity training.

LIMITATIONS

Despite the strengths of the randomized controlled design and adequate sample size, the present study has certain limitations. First, the study population consisted exclusively of healthy young adults aged 18-25 years; therefore, the findings cannot be generalized to older adults or individuals with cardiovascular, metabolic, or respiratory disorders. Second, the duration of the intervention was limited to 6 weeks, which may not be sufficient to assess long-term cardiovascular adaptations or sustainability of the observed benefits.

Additionally, the study relied primarily on physiological and subjective outcome measures such as blood pressure, pulse rate, respiratory rate, oxygen saturation, and perceived exertion. Advanced cardiovascular markers, including heart rate variability, VO_2 max, lipid profile, and inflammatory biomarkers, were not evaluated. The absence of long-term follow-up also limits the ability to determine whether the improvements were maintained after cessation of the intervention.

Lastly, although participants were advised not to engage in other forms of exercise during the study period, complete control over lifestyle factors such as diet and daily physical activity could not be ensured.

Future Scope

Future research should focus on conducting long-term intervention studies with extended follow-up periods to evaluate the sustainability of cardiovascular improvements achieved through combined exercise and yoga programs. Including diverse populations, such as older adults, sedentary individuals, and patients with cardiovascular or metabolic disorders, would enhance the generalizability of findings. Incorporation of advanced cardiovascular and metabolic parameters, including heart rate variability, VO_2 max, lipid profile, and stress biomarkers, would provide deeper insight into the physiological mechanisms underlying the observed benefits. Further studies may also explore different yoga styles, intensities, and sequencing patterns when combined with high-intensity interval training or aerobic exercise. Comparative studies assessing cost-effectiveness, adherence, and injury prevention could aid in developing optimal exercise prescriptions for clinical and community settings. Such research would contribute to evidence-based guidelines promoting safe, holistic, and effective cardiovascular conditioning strategies.

CONCLUSION

In conclusion, integrating yoga with either high-intensity interval training or aerobic exercise offers a safe, effective, and comprehensive strategy for improving cardiovascular health in healthy young adults. These findings support the inclusion of yoga as a complementary component in exercise prescription and physiotherapy practice for optimizing cardiovascular outcomes

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