

EFFECTS OF AN 8-WEEK CIRCUIT TRAINING PROGRAM ON CARDIOVASCULAR ENDURANCE AND HEART RATE RECOVERY AMONG COLLEGE STUDENTS IN DISTRICT OKARA, PAKISTAN

1. Mujahid Ali (corresponding Author)

MPhil Scholar, Department of Physical Education and Sports Sciences, Islamia University Bahawalpur, Bahawalpur, & Lecturer, Physical Education, Higher Education Department, Punjab

Email: syedmujahid04@gmail.com

2. Dr. Muhammad Badar Habib

Associate Professor, Department of Physical Education and Sports Sciences, Islamia University, Bahawalpur, Bahawalpur

Email: badar.habib@iub.edu.pk

Abstract

This current research was designed to investigate the impact of an 8-week circuit training program on cardiovascular endurance and heart rate recovery (HRR) in college students at the Okara District in Punjab, Pakistan. Circuit training is known as a mixture of aerobic and resistance training and performed in a continuous pattern with minimal rest periods is known to improve a variety of dimensions of physical fitness in a high-performance within restricted timelines. It was conducted in the form of a randomized pre-test post-test experimental design with 40 male students between the ages of 16 and 19 years. The participants will be randomly divided into an experimental group (n = 20) and a control group (n = 20) which will undergo circuit training three times a week over a period of eight weeks and regular daily lives respectively. The Cooper 12-Minute Run Test of cardiovascular endurance and the Polar H10 heart rate monitor of HRR were used to collect data. The outcomes showed that there was a marked difference in VO₂ max between experimental (pre-test mean = 42.99, post-test mean = 47.33) and control groups (pre-test mean = 43.07, post-test mean = 43.94). In the same case, the HRR improved considerably in the experimental (pre-test mean = 32.25 bpm, post-test mean = 35.30 bpm; $p < 0.01$) group with a higher post-exercise heart rate recovery. The statistical analysis proved that the improvements observed were directly related to circuit training. The results confirm the efficacy of circuit training in improving cardiorespiratory endurance, autonomic heart performance and total cardiovascular fitness among young adults. Considering time-efficiency, low equipment, and high physiological advantages, circuit training could be an efficient approach that could be included in college physical education programs and youth wellness programs.

Keywords: *Circuit training, Cardiovascular endurance, Heart rate recovery, College students, Physical fitness, Pakistan.*

Introduction

Circuit training is a type of multi-component exercise that improves strength, endurance, agility and other physiological aspects, and it includes a sequence of aerobic and resistance exercises with little rest in between (Annasai et al., 2023; Mahalingam et al., 2024). It is well-known for its efficiency and the high level of improvements in cardiovascular endurance and muscular fitness achieved in a short time (Achamo et al., 2022), evidenced by improvements in performance, e.g., shuttle run results (Mayorga et al., 2013). Circuit training can provide a constant cardiovascular demand, enhancing cardiovascular endurance and heart rate recovery (HRR) (Akram, 2024). Cardiovascular endurance, or how well the heart, lungs and circulatory system supply oxygen to exercising muscles, is crucial for prolonged exercise and associated with lower cardiovascular disease risk (Malone, 2024; Vanyushin et al., 2020). HRR is an indicator of the function of the autonomic nervous system and represents the rate of post exercise heart rate return, and is a non-invasive indicator of cardiovascular fitness, in that a faster recovery represents better parasympathetic reactivation and lower cardiovascular risk (George et al, 2016; Micheal et al, 2017). Despite these advantages, physical inactivity is a

worldwide issue and in Pakistan, a large proportion of adolescents are not achieving the recommended activity levels (Afzal et al., 2017). But, limited studies have been conducted that have investigated the combined effect of circuit training on cardiovascular endurance and HRR in college students in Pakistan, therefore this study is conducted in District Okara to find out the effect of circuit training on cardiovascular endurance and HRR from pre to post test in college students to give evidence based recommendations to improve the fitness and well-being of the youth. (Mahalingam et al., 2024).

Statement of the Problem

The physical fitness of college students has also declined because of academic stress, lack of physical activity and sedentary lifestyle, and many are not physically active enough to meet the recommended fitness guidelines with lower levels of VO_2 max, less cardiovascular endurance, and slower HR recovery (Fan et al., 2020). The deficits are substantial, with the association of poor cardiorespiratory fitness with increased risk of cardiovascular and metabolic diseases, decreased energy and decreased stress resistance (Fan et al., 2020). This decreases pupils' endurance and their ability to recover, which has a negative impact on their stamina, attainment and wellbeing, and long-term sitting increases the risk of obesity, type 2 diabetes and cardiovascular disease (Lee et al., 2018). While exercise is effective, due to time constraints, students participating in regular exercise may be limited, requiring effective interventions within limited time, such as circuit training which has been shown to be effective in improving cardiovascular fitness within short time frames (Yin et al., 2025). A research gap has, however, been identified, especially in the Pakistani context as limited research has been conducted on college populations while few studies have been conducted that included the effect of circuit training on aerobic capacity alongside HRR in sedentary students (Mayorga et al., 2013). In view of this, the current study seeks to contribute to existing literature by examining the impact of an 8-week circuit training program on cardiovascular endurance and heart rate recovery to afford empirical evidence to improve student health, fitness, and long-term well-being.

Aim of this Study

This experimental study aims to measure the effects of an 8-week circuit training program on cardiovascular endurance and the rate of recovery of the heart rate among college students, pertaining to the fact that a physically fit youth is essential for more productive contribution in the development of country.

Objectives of Study

- To determine the role of physical activity on physical fitness of youth.
- To measure the effects of circuit training on physical fitness of college students.
- To increase cardiovascular endurance and heart rate recovery using 8-week circuit training on college students.

Hypothesis

H1: Circuit training has positive effect on cardiovascular endurance and heart rate recovery

H0: Circuit training has no effect on cardiovascular endurance and heart rate recovery

H2: Circuit Training has negative effect on cardiovascular endurance and heart rate recovery

Significance of Study

The practical and theoretical importance of this research is the evaluation of the effect of circuit training on heart rate recovery (HRR) and cardiovascular endurance for college students, which are two important issues that have not been investigated previously. Although HRR reflects autonomic nervous system activity and cardiovascular fitness, it is not well

documented in previous literature that has focused on VO_2 max and RHR. Circuit training is an effective aerobic and resistance training program in a short amount of time; it has been demonstrated to improve aerobic capacity and endurance.

Literature Review

In sports science, circuit training is well known for enhancing several physiological parameters, such as cardiovascular endurance and heart rate recovery (HRR). Incorporates both aerobics and resistance training to improve fitness. This review presents evidence of its effects on cardiovascular endurance and HRR in college students and identifies the most important adaptations and implications for fitness.

Cardiovascular Endurance

Physical inactivity is a global problem and physical fitness for longterm health is underachieved for many adolescents including those of Pakistan, as they do not achieve the required level of physical activity as recommended (Afzal et al., 2017). Results indicate that circuit training is effective for achieving greater aerobic capacity, with 8 weeks of CT resulting in an increase of $+6.79 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ in male college students (Duangsawang et al., 2023) to 5-9% in female athletes following short-term training interventions (Boby et al., 2025). However, there were some variations in the results, with moderate-intensity training having little to no effect on VO_2 max changes in female volleyball players (Arjuna et al., 2022). There are also age-specific benefits, such as the elderly (Baharavar et al. 2025) and even potential for the prevention of age-related decline (Menz et al. 2021); and meta-analysis reporting an average improvement of approximately 6% VO_2 max (Ramos et al. 2021).

Heart Rate Recovery (HRR)

HRR is one of the most important parameters for autonomic function and cardiovascular autonomic health and a measure of the balance between sympathetic activity and parasympathetic reactivation after exercise (Hernesniemi et al., 2020). High HRR is linked to better cardiac efficiency and lower risk for disease. However, evidence for circuit training and HRR is limited and conflicting. Research with young athletes has shown that 10-minute high-intensity circuit training sessions did not cause changes in HRR, though they did result in an increase in overall fitness (Salagas et al., 2020), and other studies have found no significant changes in HRR despite improvements in overall fitness (Garcia et al., 2020). Additionally, recent literature shows that very few studies have quantified HRR outcomes in young and college-age groups and most studies focused on general measures of fitness rather than autonomic recovery (Engel et al., 2019).

Circuit Training and Its Applications

Circuit training was originally introduced by Morgan and Adamson in 1959 and is a sequence of stations of exercises intending to involve different muscle groups in the circuit with a controlled rest between exercises (Bompa et al., 2015). Research indicates it leads to increased aerobic capacity, decreased resting heart rate, and increased exercise endurance in youth (Menz et al., 2021), and increased motivation and enjoyment of exercise (Dan, 2025). It is time efficient, and can be adapted to college students, but there is limited evidence on flexibility and balance (Lee et al., 2021). Although it has been known to have many beneficial effects, there is yet a lack of knowledge about its combined effect on cardiovascular endurance and HRR in collegiate populations, especially in areas like Okara (Mayorga et al., 2013). Additionally, its versatility with digital platforms and group fitness environments has seen a resurgence in popularity recently, further highlighting its current relevance in the fitness landscape (Thompson et al., 2023; Duggan, 2024).

Physiological Adaptations

Circuit training creates several adaptations such as improved muscle strength, lean mass and neuromuscular efficiency, especially during early training (Ramos et al., 2021; Tallent et al., 2021). It improves cardiovascular function by increasing stroke volume, capillarization and mitochondrial activity, increasing VO_2 max and reducing resting heart rate (Getty et al., 2018). Increased levels of anabolic hormones and hormonal adaptations promote muscle growth and benefits the metabolic pathway, whereas decreased insulin resistance and fat mass improve overall health (Zouhal et al., 2022; Rezaeinezhad et al., 2022). Further, circuit training has a positive effect on body composition and cardiometabolic risk factors (Kim et al., 2019).

Circuit Training in Sports and Collegiate Populations

In the sporting world, circuit training has proven to be effective in improving strength, speed, agility, and endurance in different sports such as basketball, volleyball, and football (Annasai et al., 2023; Ibrahim et al., 2018). It is an effective cross training technique for endurance athletes, and it enhances neuromuscular performance and sports specific skills (Hermassi et al., 2020; Ramos et al., 2021). Circuit training has been proven to enhance muscular endurance, flexibility, body composition and cardiovascular fitness among college students (Gizaw et al., 2025; Pugliese et al., 2025; Lee et al., 2022). Interventions of as little as 4 weeks through as long as 12 weeks have shown improved VO_2 max, endurance, and fitness (Sonchan et al., 2017; Gonsi et al., 2025; Lee et al., 2021).

Research Methodology

The chapter identifies the research design, population, sampling and sample size, protocol of the circuit training, data collection procedures, and data analysis methods which will be used in this chapter to investigate the effects of circuit training on heart rate recovery (HRR) and cardiovascular endurance among collegiate students.

Research Type & Design

It is experimental type of research that can be used to improve internal validity as it involves comparison of changes over a period using a treated and untreated group. The use of random assignments and control arms will assist in ensuring that the differences observed in the outcomes can be said to have been caused by circuit training and not by selection bias and other extraneous factors. This study uses a randomized controlled pretest–posttest design.

Population and Sampling

The study site is Tehsil Depalpur, which has 15 colleges offering admission for 11th and 12th grade. The total number of students being admitted in these 15 public and private sector institutes is approximately 3000. The selected samples were randomly distributed into two groups, experimental ($n=20$) and control($n=20$). Each of the candidates would be subjected to health screening IPAQ (International Physical Activity Questionnaire) to ensure they would be healthy and fit to exercise.

Measurements

Measurement can involve various instruments and scales, ranging from simple tools Like rulers and thermometers to complex physiological measurements or psychological questionnaires.

IPAQ

The IPAQ 7-item shot was used to determine the PA level of the participants depending on the days and minutes per day of performing PA during the last seven days (Craig et al., 2003). IPAQ measured three forms of PA, that is, walking, moderate and vigorous intensity activity. The number of times the resting metabolic rate occurs is referred to as the metabolic equivalent of takes (METs). The calculation of PA was done in accordance with the energy expenditure, moderate and vigorous intensity and sitting time. Energy expenditure was

presented in form of metabolic equivalent times duration of time and week (METs minutes x week). The formula that was applied to determine the IPAQ score was walking METs (walking minutes x days x 3.3), moderate METs (moderate minutes x days x 4.0) and vigorous METs (vigorous minutes x days x 8.0). Less than 600 MRTS/week is considered low activity, 600-3000 METs/week is considered moderate activity, and more than 3000 METs/week is considered vigorous activity. (Deng et al.,2008). The test-retest reliability of Spearman's rho demonstrated the good reliability and validity of IPAQ, =.66 to.88 (mean=.76) (Habib et al., 2020) & (Craig et al., 2003). IPAQ is an energy expenditure method which is valid and founded on moderate and vigorous intensity and sitting time (Craig et al., 2003; Guthold et al., 2008). The IPAQ can be offered in 21 languages, such as Urdu and the IPAQ version demonstrates high reliability and validity (Habib et al., 2020).

Validity of Cooper test

The 12-minute run (CRT) of Cooper is a common method of estimating a maximal aerobic capacity (VO₂ max) based on distance run in 12 minutes. Studies conducted in the field demonstrate moderate-to-strong correlations of VO₂max laboratory measures in healthy young people (including college-age).

Reliability of Cooper test

The research points out there is extreme consistency when the CRT developed in young adults is repeated. The overall reliability coefficient 0.96 in three trials was reported by Penry (2011) based on his generalizability study that used healthy college-aged volunteers (mean=21.8 years).

Heart Rate Recovery

Heart rate recovery is measured by using Polar H10 heart rate monitor (Polar Electro, Finland) connecting via Bluetooth to a smartphone containing Polar Beat (v.3.5.8), attach to measure heart rate recovery. HRR is measured after 15 seconds and 1 minute following the completion of 30s all out circuit training program. According to (Mongin et al, 2023), HRR measured at 15 seconds, and 1-minute post-exercise is considered the most reliable.





- After the exercise test (e.g. Cooper Test), heart rate is measured after the exercise immediately (Peak HR).
- Then HR is tracked again after a certain recovery period (1-minute 15s).
- $HRR = \text{Peak HR} - \text{HR at recovery time}$

Validity of Polar H10

The Polar H10 still matches ECG immediately after exercising. In cycling test, there was no major change demonstrated between Polar H10, and ECG mean HR in post-ex test measurement. Whereas one of the groups reported a statistically significant bias under maximum exercise ($p < 0.001$), the relative magnitude of error in practice was extraordinarily small (sub-1bpm level). In general, the device monitors fast decay of HR with minimal lag or inaccuracy in healthy adults (Schaffarczyk et al., 2022).

Reliability of Polar H10

The Polar H10 demonstrates great repeatability as well. The results of a recent study repeated exergaming sessions of Manser (2024) showed that the mean RR intervals recorded by Polar H10 had good to excellent test -retest reliability (no systematic error). Practically this implies that as far as the identical user repeats runs or exercises, his HR outputs provided by the Polar H10 are going to be incredibly consistent.

Variable	Measuring Tool	Unit
Cardiovascular Endurance	Cooper 12-min Run Test	meters
Heart Rate Recovery	Heart Rate Monitor (PH10)	beats/min

Data Analysis

The Statistical Package of the Social Sciences (SPSS software (V-26) is used to analyze the data. A repeated-measures ANOVA with factors Group (circuit vs. control) and Time (pre vs. post) is used to test and confirm an interaction effect of the intervention on outcomes. When assuming conditions in ANOVA cannot be met or when the limitations of the sample size are exceeded, then suitable non-parametric tests can be applied. Also, paired t-tests will be made to assess the pre-test against the post-test mean of each group and independent t-tests to determine the change between groups or score.

Results

I used SPSS version 25 statistical software in this research. This research aim was to provide insight into the improvements that may happen in cardiovascular endurance and heart rate recovery that may be attributed to use of CT, which is a well-known and used type of training in the sporting industry. To thoroughly assess the effectiveness of this training regimen we have used a stringent analytic methodology. We used the t -test as a statistical tool to

estimate the pre-training and post-training speed of the throws. The choice of the independent sample t-test was inspired by the fact that it can compare the means of pre-intervention and post-intervention measures within the individual conditions and consider the fact that the data is paired. The use of the One-way ANOVA was because it compares the meanings of the various groups whether they are the same or not through the comparison of the variance between the groups to the variance within the group.

Frequency of Demographic Information

The demographic profile of the participants is given in Table 4.1. that the average age of the respondents was approximately ($M=17.6$) years, with a standard deviation of 0.81. All participants in this intervention are male. Regarding the intervention groups, the study consisted of an equal split between two groups: 50% ($N=20$) of the respondents were in the control group, while the other 50% ($N=20$) were in the experimental group.

Table 4.1:

Demographic information of Control and Experimental group ($N=40$)

<i>Respondents Characteristics</i>	<i>F (%)</i>	<i>M $\pm$ SD</i>
Age		17.6 $\pm$ 0.81
Male	40	
Intervention Group	Control 20 (50) Experimental 20 (50)	

Normality of Data

Table 4.2 has the results of normality tests Kolmogorov-Smirnov test and Shapiro-Wilk test with a sample size of 40 (df) of four variables, VO2 Pre, VO2 Post, HRR Pre, and HRR Post. In the case of VO2Pre, the Kolmogorov-Smirnov level is 0.190 accompanied by a significance level (.001), and the Shapiro-Wilk level is 0.924 with $p = .010$. Likewise, in VO2Post, there are values of 0.150 ($p = .023$) and 0.928 ($p = .014$), respectively. The results obtained after all the results of both tests are lower than 0.05 show that VO2 variables are not normally distributed substantially.

The same trend is followed by the variables of heart rate. The Kolmogorov-Smirnov and the Shapiro-Wilk both have values of 0.183 ($p = .002$) and 0.859 ($p = .001$) in HRR Pre and HRR Post, respectively. Once again, the values of all the significant values are lower than the threshold of 0.05, which proves that the data are not normally distributed. Both tests are always telling that none of the variables is normally distributed, and thus non-parametric statistical procedures could be more applicable to use in the future.

Table 4.2

Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
VO2 Pre	.190	40	.001	.924	40	.010
VO2 Post	.150	40	.023	.928	40	.014
HRR Pre	.183	40	.002	.859	40	.000
HRR Post	.166	40	.007	.895	40	.001

Pearson Correlation between Cardiovascular Endurance and Heart Rate Recovery

The measured parameters were found to be correlated with each other with a positive correlation (Pearson, r) value of 0.93 observed between cardiovascular endurance (CVE) and heart rate recovery (HR) as given in Table 4.3

Table 4.3:

Correlations between CVE and HRR

		<i>CVE</i>	<i>HRR</i>
CVE	Pearson Correlation	1	0.93*
	N	40	40
HRR	Pearson Correlation	0.93*	1
	N	40	40

The *null hypothesis* states that there is no correlation between the cardiovascular endurance (CVE) and heart rate recovery (HR), and *alternative hypothesis* states that there is a correlation between cardiovascular endurance (CVE) and heart rate recovery (HR). The sample correlation coefficient is 0.93 which is positive relationship between cardiovascular endurance (CVE) and heart rate recovery (HR) then we reject *null hypothesis*.

IPAQ Analysis

Table 4.4 shows the physical activity of the participant during a week in MET-minutes of the three intensity levels walking, moderate, and vigorous activities. The data demonstrates that the person walks 5 days a week with a 30 minutes per day duration at a MET value of 3.3 which gives a 495 MET-min/week. The moderate activity is 40 minutes of exercise 3 days per week with a MET of 4.0 which contributes 480 MET-min/week, and the vigorous activity is 20 minutes of exercise 2 days per week with a MET of 8.0 which contributes 320 MET-min/week. Less than 600 MRS/week is considered low activity, 600-3000 METs/week is considered moderate activity, and more than 3000 METs/week is considered vigorous activity. The total amount of physical activity is 1295 MET-min/week, which is the sum of physical activity of the person, and, according to traditional IPAQ classification criteria, it places the person in moderate physical activity, which is a good indicator of an acceptable level of participation in regular exercise.

Table 4.4:

IPAQ Table of Results

<i>Activity Level</i>	<i>Day/Week</i>	<i>Minutes/Day</i>	<i>MET Value</i>	<i>MET-min/week Calculations</i>	<i>Total MET-Min/week</i>
Vigorous Activity	2	20	8	2 x 20 x 8	320
Moderate Activity	3	40	4	3 x 40 x 4	480
Walking	5	30	3.3	5 x 30 x 3.3	320
Total Physical Activity					1295

Comparison between Control Group and Experimental Group with Pre and Post on Cardiovascular Endurance (N=40)

Table 4.5 shows the differences between pre and post scores for cardiovascular endurance following an intervention. The scores of the post-test (47.33) were higher than the pre-test (42.99), indicating that there was an improvement in cardiovascular endurance in the participants. The post-test variance (17.72) is greater than the pre-test variance (3.69) which would seem to indicate that there is more variance in the post-test scores, but there were an equal number of cases in the sample (40). Good correlation (0.47) is seen between the pretest

and the post test scores, and the correlation is positive. The t statistics (-7.39) obtained are significantly larger than the critical values of one-tailed (1.68) and two-tailed (2.02) and the p-values are essentially equal to 0.00, which implies that the difference is significant. The results are therefore quite suggestive that the intervention was highly beneficial and had a significant effect on the heart and circulation.

Table 4.5:

T Test (Paired Two Sample for Means) Between Experimental and Control Group on Cardiovascular Endurance for Pre and Post Test

Cardiovascular Endurance	Pre Test	Post Test
Mean	42.99	47.33
Variance	3.69	17.72
Observations	40.00	40.00
Pearson Correlation	0.47	
Hypothesized Mean Difference	0.00	
df	39.00	
t Stat	-7.39	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.68	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.02	

Figure 4.1 represents data distribution of tested parameters. In control sets, there was no clear difference in treatment means of cardiovascular endurance while in experimental group there was a clear significant difference (as standard error bars are not overlapping) suggesting our tested interventions have positive role on tested physiological performance.

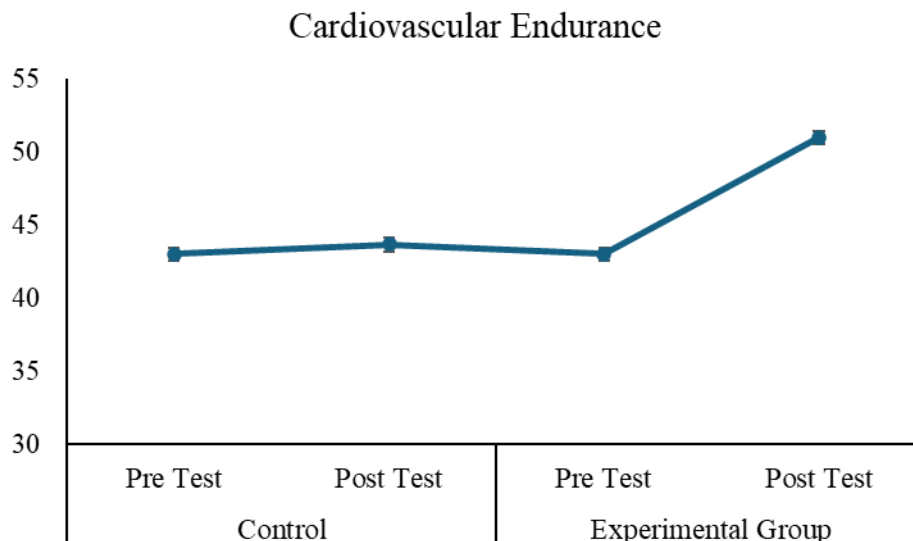


Figure 4.1. Cardiovascular Endurance of Control and Experimental Group

Comparison between Control Group and Experimental Group with Pre and Post on Heart Rate Recovery (N=40)

The paired t-test in Table 4.6 shows statistically significant difference between the pre-test and post-test of recovery of the heart rate. The heart rate recovery in posttest was higher than the pretest, 35.30 as compared to 32.25, indicating that the intervention improved heart

rate recovery. The number of observations for the pretest ($n = 112$) and posttest ($n = 500$) are different, so that the comparison is not balanced, but the number of observations remains equal ($n = 40$) in both pre and posttest. The t-value that has been calculated ($t = -8.31$) is significantly larger than the critical values of one-tailed (1.68) and two-tailed (2.02) tests, and the p-values (0.00) are significantly less than the standard significance level of 0.05. This is a clear indication that the difference that is observed is not because of chance. Therefore, the findings imply that the intervention had a significant impact on the recovery of HR.

Table 4.6

T Test (Paired Two Sample for Means) Between Experimental and Control Group on Heart Rate Recovery for Pre and Post Test

Heart Rate Recovery	Pre Test	Post Test
Mean	32.25	35.30
Variance	1.12	5.50
Observations	40.00	40.00
Pearson Correlation	0.25	
Hypothesized Mean Difference	0.00	
Df	39.00	
t Stat	-8.31	
P(T<=t) one-tail	0.00	
t Critical one-tail	1.68	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.02	

Figure 4.1 represents data distribution of tested parameters. In control sets, there was no clear difference in treatment means of heart rate recovery while in experimental group there was a clear significant difference (as standard error bars are not overlapping) suggesting our tested interventions have positive role on tested physiological performance.

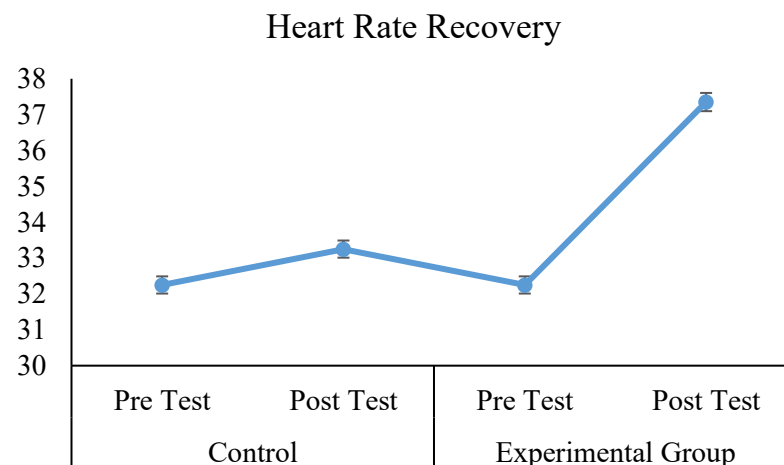


Figure 4.2. Heart Rate Recovery of Control and Experimental Group

ANOVA Test on Cardiovascular Endurance

In table 4.7 the one-way ANOVA test shows that intervention has a very strong effect on cardiovascular endurance. The sample sizes for both groups were equal ($n = 79$) although there was a significant difference in the average scores of 2.52 (variance = 1.25) in the pre-intervention condition to 45.20 (variance = 15.45) in the post-intervention condition which is a significant improvement. This is backed up in the ANOVA table by the fact that the between-group sum of squares ($SS = 71,944.82$) is very large as compared to the within-group SS (1,302.45), which means that the additional change in the groups is caused by the intervention, as opposed to random error. The F statistic ($F = 8617.14$) is much larger than the critical value ($F_{crit} = 3.90$) and the p value is almost 0.00, indicating that the difference between the groups is statistically significant. Overall, the results of this study are encouraging to conclude that the intervention had a highly significant and positive impact on cardiovascular endurance.

Table 4.7

One way ANOVA on Cardiovascular Endurance

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	71944.82	1.00	71944.82	8617.14	0.00	3.90
Within Groups	1302.45	156.00	8.35			
Total	73247.27	157.00				

ANOVA Test on Heart Rate Recovery

The results of the one-way ANOVA of the heart rate recovery at the pre-intervention and post-intervention level are presented in Table 4.8, with a statistically significant and evident enhancement of the parameter. As demonstrated by the summary statistics, the sample size of both groups was the same ($n = 79$) and the mean rose significantly (2.52 vs. 33.81), representing the improved heart rate recovery. Variances also went up a notch, increasing by 1.25 to 5.59, which means that there was a little variation in the post-test responses. The outcomes of the ANOVA show that the between groups sum of squares ($SS = 38,675.85$) is significantly larger than the within groups SS (533.87) indicating that the effect of the intervention has contributed a major part of the variation. Moreover, the calculated F -value (11,301.24) is very large in the view of the critical value ($F_{crit} = 3.90$), and the p -value (0.00) is far less than the significance level (0.05). This confirms the fact that the pre/post intervention difference in heart rate recovery is very significant representing that the intervention has a very strong positive influence.

Table 4.8

One way ANOVA on Heart Rate Recovery

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	38675.85	1.00	38675.85	11301.24	0.00	3.90
Within Groups	533.87	156.00	3.42			
Total	39209.72	157.00				

Discussion

The results demonstrated that circuit training increases cardiovascular endurance by increasing oxygen utilization, cardiac strength and stamina. This is particularly applicable for college students who may be less active because of their academic and sedentarism lifestyle, which may make them susceptible to fitness loss (Scroggs et al., 2025). Heart rate recovery

(HRR) was also improved, representing a better autonomic regulation and greater HR recovery, in line with George et al. (2016), and Michael et al. (2017). Better HRR also indicates a higher recovery potential and a lower cardiovascular risk.

Circuit training is also time efficient and convenient for young adults. It is a combination of aerobic and resistance exercises that brings about significant improvements even in brief training sessions, which is beneficial for keeping up with training, as emphasized by Romas et al. (2021). It is relevant in the context of Pakistan, where young people's involvement is significantly low (Afzal et al., 2017), and health effects of short-term interventions.

This study fills a gap, as it offers localized support from Pakistani college students. In line with the findings by Yin et al. (2025), there are significant improvements in the endurance and HRR within 8 weeks that justify the inclusion of these programs in curricula. The 2 benefits are a testament to the all-round physiological benefits of circuit training.

Moreover, the results indicate that structured activity reduces academic pressure and/or inactivity effects, which is consistent with the findings of Lee et al. (2018). In general, the 8-week program proved to be an effective and feasible intervention for promoting cardiovascular health, stress coping and well-being of college students in District Okara.

Conclusion

The study concludes that the 8 weeks of circuit training significantly enhances the cardiovascular endurance of college students in district Okara as well as their heart rate recovery (HRR). It emphasizes circuit training as a well-structured and time-saving method that improves oxygen utilization, strengthens cardiac function, and increases stamina, especially among students who lack physical activity and those with academic demands. Better HRR means better autonomic regulation, decreased cardiovascular risk. Another important research gap in Pakistan was also filled in the study as it gave empirical evidence of the circuit training in collegiate population. In general, circuit training is an effective, inexpensive, and scalable approach to enhance physical fitness, stress management, and wellbeing across the lifespan.

Recommendations

- Use larger, more varied samples from multiple regions, to increase generalizability.
- Expand the duration of intervention (12-16 weeks) and conduct follow-up assessments to determine long-term consequences and maintenance of HRR and endurance benefits.
- Manipulate key variables (diet, sleep, stress, hydration and physical activity) to eliminate the influence of these factors on circuit training.
- Use sophisticated measurement strategies (VO₂ max, HRR based on ECG, and wearable devices) to gain better physiological understanding.
- Compare different exercise modalities (HIIT, aerobics, resistance training, etc.) to identify how effective each one is.

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