



Effects of Circuit Training on Cardio-Respiratory Endurance Among College Students

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Abstract

The main purpose of the study was to investigate the effects of circuit training on cardiorespiratory endurance among college students. The thirty healthy and volunteered students were selected as subjects through Physical readiness questionnaire (PAR-Q) having an age of 18-22 years. Subjects were equally divided into two groups as Experimental and Control. The data on cardiorespiratory endurance was collected (before and after the treatment) of each subject of both groups through the Copper test. The treatment of circuit training was given to the experimental group three times a week on alternate days for 12 weeks. During the same period, the control group did not take part in any sort of special training except routine life activities. The data were analyzed by applying the paired sample t-test. The results show that circuit training of 12 weeks significantly improved cardio respiratory endurance in experimental group ($p < 0.05$) than control group.

Key Words: Circuit Training, Cardio-Respiratory Endurance, College Students

Introduction

It is essential for an individual to be physically fit in order to lead a happy and prosperous life. Physical fitness makes an individual perform the assigned responsibilities efficiently and effectively. She/he is mentally sharper and more physically active (Katapally *et al.*, 2016). Physical fitness has been highlighted in various ways. Simply it is the capacity of a person to carry out daily routine assignments without undue fatigue and has sufficient energy to enjoy leisure-time pursuits and meet the unanticipated emergencies (Navarrete-Villanueva *et al.*, 2020). It may also be defined as to execute the daily tasks efficiently and effectively (Hanssen-Doose *et al.*, 2020).

There is a further division of physical fitness into two parts which are skill-related physical fitness and health-related physical fitness. Skill-related physical fitness is that fitness which helps in the execution of sports and athletic activities skillfully. It boosts up the performance of an athlete. It includes all those components that assist in to show better performance in sports-oriented activities. The components of skill-related physical fitness are six in number. These are speed, power, coordination, balance, agility and reaction time (Mukherjee, Nayek, & Chatterjee 2016).

As far as health-related physical fitness is concerned, it is that sort of fitness that enables an individual to live and stay physically healthy. It is the need of every individual irrespective of gender, profession and age in order to lead a healthy life. Health-related physical fitness is equally important to every individual in order for a healthy and prosperous life. It also provides a foundation for skill-related physical fitness. An athlete cannot achieve skill-related physical fitness without health-related physical fitness. This is the main reason that physical educators and medical experts stress upon health-related physical fitness equally (Romero *et al.*, 2010). Health-related physical fitness enables an individual to show resistance to various kinds of diseases and illnesses because it improves the immune system of the body (Collins & Staples, 2017). An individual is more productive. He/she enjoys a sound sleep. All the systems of the body carry out their respective functions properly and effectively. It makes an

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individual free from various sorts of psychological problems like anxiety, depression etc.; it creates self-confidence and emotional stability in a person (Rodriguez-Ayllon *et al.*, 2018).

There are five components of health-related physical fitness. Each component has its own role in the maintenance of health-related physical fitness. The components of health-related physical fitness are flexibility, muscular strength, muscular endurance, body composition and cardiorespiratory endurance. Flexibility is concerned with the joints of the body. It is the range of movement at a joint or joints. Muscular strength deals with the application of force by a muscle or muscles of the body in a single effort. Muscular endurance is the ability of a muscle or muscles of the body to carry out an activity for a sustained period of time. Body composition refers to the proportion of fats and lean body mass of an individual ([Behan, Belton, Peers, O'Connor, & Issartel, 2020](#)).

Cardiorespiratory endurance is the key component of health-related fitness. It is the ability of the heart, lungs and blood vessels to deliver the adequate quantity of oxygen (O₂) and nutrients to cells of working muscles. In the cells of working muscles, energy is produced from the nutrients in the presence of O₂. The energy is used by the working muscles to carry on the task/activity for a longer time without undue fatigue ([Cheng, Chiu, & Su, 2019](#)). Respiratory system and cardiovascular systems of the body play an important role in achieving the quality of cardiorespiratory endurance. More O₂ is inhaled into the lungs, and carbon dioxide (CO₂) is exhaled during physical activity. The heart also pumps more oxygenated blood into the tissues of the body for energy production to carry on the activity for a longer period of time. In the same, the blood also takes of the CO₂ from the cells produced during the production of energy process and carries to the lungs by right ventricle of the heart for expulsion from the body (Vanyushin, Fedorov & Kuznetsova, 2020).

Cardiorespiratory endurance provides a base for other components of health-related fitness. It enhances the working capacity of an individual, and hence the daily routine tasks are performed efficiently without fatigue. He/she recovers quickly after performing the task (Ruiz *et al.*, 2006). It decreases the risks of cardiovascular diseases. It minimizes the chances of obesity and obesity is not a problem itself, but it also paves the way to other health problems like coronary heart diseases, stress and diabetes ([Bocalini *et al.*, 2012](#)). It is also used to measure and determine the fitness and progress level of a person, respectively (Ross *et al.*, 2016).

Cardiorespiratory endurance can be measured with a different test like the Copper test, Harvard step test, maximal oxygen uptake (VO₂) and treadmill test. The Copper test is mostly used for measuring cardiorespiratory endurance because it does not need special equipment and mathematical formulas. It was developed by Kenneth Copper in 1968. The main objective of Kenneth Copper behind the introduction was to determine the aerobic fitness of military personnel. The usual requirements which are necessary to conduct the test are a 400m running track, a whistle, a pencil and notebook. A subject is given 12 minutes to cover maximum distance in the stipulated time. He/she is free to run or walk. Therefore, it is also called 12 minutes run/walk test. With the blow of the whistle, a subject starts run/walk-in running track. A lap scorer counts laps covered by him/her. At the end of 12 minutes, the whistle is again blown, and the subject stops run/walk. The distance of all laps and plus the segment of lap covered by him/her in 12c minutes are calculated in meters. The total distance is compared with the setting values in order to verify whether the subject is excellent, above average, average, below average or poor ([Batista, Romanzini, Castro-Piñero, & Ronque, 2017](#)).

As far as the Harvard step test is concerned, it was developed by Lucien Brouha in 1943 with the help of his associates. The equipment which is required to conduct the mentioned test is a platform of 50.8cm high, stopwatch and metronome. The subject has to step up on and back down from the platform. The up and back down process takes two seconds. Thus, a subject has to complete 30 steps per minute and will continue it for five minutes. If a subject becomes exhausted before five minutes and cannot carry on the stepping rate for 15 continuous seconds, in both cases (expiration of 5 minutes or exhaustion), he/she sits down immediately. His/her heartbeats are counted three times after finishing, i.e., from 1 to ½ minutes, 2 to 2 ½ minutes and 3 to 3 ½ minutes. All the heartbeats of three times are added and put in the equation = $100 \times \text{test duration in seconds} / 2 \times \text{sums of heartbeats in the recovery period}$. The derived figure is compared with the already set values in order to decide his/her cardiorespiratory endurance status ([Elsaidy, 2011](#)).

There are various factors that affect cardiorespiratory endurance. Some of the factors are lack of balanced diet, the proper taking of sleep and rest and use of alcohol ([Arboix-Alió *et al.*, 2020](#)). Lack of physical activity is

also one of the main factors that have affected cardiorespiratory endurance. In olden days more of the tasks were performed by hands, and thus human body was used. Because of the advancement in the modern era, most of the tasks are carried out with the help of various machines. Man has become dependent on these machines. The mentioned deplorable situation has paved the way to deterioration of cardiorespiratory endurance.

The importance of physical activity in the enhancement of cardiorespiratory endurance has been clearly shown. Regular performance enhances the cardiovascular system. The muscles of the heart become strong. Because of the mentioned quality of the heart, the heart pumps blood into the tissues of the body efficiently and effectively. The stroke volume of the heart increases, which results in the enhancement of cardiac out-put ([Buzzachera, Correale, & Liberali, 2020](#)). Likewise, the muscles of the lungs are strengthened. More O₂ is inhaled, and CO₂ is exhaled. The vital capacity is developed. Thus, the lungs perform its assigned task in a better way ([Petkov, 2020](#)). Physical activity reduces the chances of obesity which is one of the basic factors of various kinds of health problems like blood pressure, diabetes and stress. It enhances the immune system of the body that protects an individual from common diseases ([Franceschin & Veiga, 2020](#)). It reduces psychological problems like stress and anxiety because the body releases endorphins hormones during physical activity. The stated hormones release tension, and one feels mentally relaxed ([McCartan et al., 2020](#)).

Physical activity and cardiorespiratory endurance have a direct relationship. Regular participation in exercises leads to improvement in the capacity of cardiorespiratory endurance (Myers et al., 2015). It is the need of the hour to adopt an effective training program for the development of cardiorespiratory endurance. Physical training is a combination of exercises that are designed to enhance the different components of physical fitness ([Karssemeijer, Aaranson, Bossers, Smits, & Kessels, 2017](#)). Circuit training is one of the types of training that comprises of different kinds of resistance exercises. It is a sort of resistance training in which body weight or equipment weight is used as resistance. It enhances both strength and endurance (Antonio Paoli et al., 2012). It may be designed for the participants according to their fitness level (Granacher et al., 2011). It comprises of 9 to 12 exercises, and each exercise is performed on time or repetitions basis at a station (A Paoli et al., 2010). It provides the opportunity for more motor engagements in a short time (Lozano, Viciano, Martínez, Cocca, & Jiménez, 2009).

Materials and Methods

Participants of the Study

The participants of the study were all those students who were boarding in the hostel of Government Post Graduate College (GPGC) of district Karak, Khyber Pakhtunkhwa (Kp) Pakistan. Thirty healthy and volunteered students were selected as subjects for the study after distribution and collection of physical activity readiness questionnaire (PAR-Q) among 142 students of the hostel of GPGC Karak. The age range of the subjects was 18 to 22 years. For the stated purpose, PAR-Q carried all the relevant queries with reference to the desired characteristics so that suitable subjects may be selected. The students who did not live-in hostel were not part of the population. Students with past or present smoking history, suffering from chronic or acute respiratory illness, having any type of physical deformity and on chronic medication were not made part of the study. In addition to that, those students who had not been taking part in exercise for more than one hour per week for six months were made part of the study. Those students were also excluded from the study who were using the medicine for acute illness. Students who were already diagnosed with cardiac or joints problems by the doctor were not selected as subjects for the undertaken study, two equal groups (experimental and control) were formed randomly from the selected subjects each of fifteen. Before participation in the study, all the subjects were informed and briefed about the purpose of the study. For the collection of data about cardiorespiratory endurance, the copper test (12 minutes run/walk) was used. The procedure of the Copper test (12 minutes run/walk) was explained and demonstrated to all subjects practically by the researcher in order to get reliable pre-test data. The written volunteer and informed consent were also collected from each subject by the researcher in order to fulfil the ethical demands of the study.

Data Collection

The height (Centimeters) and weight (Kilogram) of each subject was measured barefooted and in light clothing

through height table and weight scale respectively. The pretest data on cardiorespiratory endurance was collected through the Copper test (12-minute walk/run). For this purpose, a 400-meter standardized track was drawn. Before treatment to the experimental group, five subjects were given 12 minutes to cover maximum distance in the mentioned time as far as possible. The run/walk started and stopped with the whistle. At the end of 12 minutes, the lapses and additional distance covered by them were noted by the next coming five subjects. The covered distance of each subject was calculated and recorded in meters. Similarly, the remaining 25 subjects were tested in groups each of five subjects. After the treatment of circuit training to the experimental group, the post-test data on cardiorespiratory endurance of each subject of both groups was collected through a copper test as the method adopted for the pretest.

Circuit Training Program

The duration and frequency of Circuit Training for the current study were 12 weeks and three times per week on alternate days, respectively. There was total 10 number of exercises, i.e., light jumping, lunges, legs raising, knee highs, sit-ups with straight legs, crunch, heel raising, burpees, squats (abdominal) and jumping jacks. For the intensity of exercises, the maximum heart rate (HRmax) was calculated by applying the equation of $[206.9 - (0.67 \times \text{age})]$ by Gellish (Gellish et al., 2007). The targeted heart rate was determined. The intensity of exercise was 55% to 65% and 65% to 75% of HRmax for 1 to 6 weeks and 7 to 12 weeks, respectively. The time of warm-up (walk and dynamic stretching exercises) and warm down (walk and static stretching exercises) was each of 10 minutes for every training session. The total time of the training session was 40 to 55 minutes, including the time of warm-up and warmed down. There were two sets of each training exercises.

Table 1.

Weeks	exercise time/interval between exercises/rest between sets	Time of training session
1-3	30 seconds/20 seconds/04 minutes	40 minutes
4-6	40 seconds/25 seconds/04 minutes 20 seconds	45 minutes
7-9	50 second/30 seconds/04 miutes and 20 seconds	50 minutes
10-12	01 minute/35 seconds/04 minutes and 30 seconds	55 minutes

Statistical Analysis

Paired sample ‘t’ test was applied in order to determine the effects of circuit training on cardiorespiratory endurance between two groups (experimental and control) and times (before vs after). $P < 0.05$ was the level of significance.

Results

Physical Characteristics of the Subjects

Table 2. The Physical Characteristics of Age, Height and Weight of Both Groups are Presented in Below.

Variable	The experimental group (n=15) Mean \pm SD	Control group (n=15) Mean \pm SD
Age (years)	19.46 \pm 1.35	20.40 \pm 1.45
Height (cm)	173.06 \pm 6.82	169.26 \pm 4.95
Weight (kg)	65.53 \pm 8.39	64.33 \pm 5.16

The above table reveals the mean values of age, height and weight of both groups before the treatment of circuit training to the experimental group. The mean values of age height and weight of the experimental group are 19.46 years, 173.06cm, and 65.53 kg respectively while the mean values of age, height and weight of the control group are 20.46 years, 169.26cm and 64.33kg respectively.

Table 3. Change in cardiorespiratory endurance of both groups after 12 weeks of circuit training to the experimental group

Variable	Group	Pretest Mean \pm SD	Post-test Mean \pm SD	F. Value
Cardiorespiratory endurance	Experimental	1745.07 \pm 253.72	2033.26 \pm 250.14	.000

Control	1768.27±241.01	1775.86±227.69	.634
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Table 3 clearly shows the cardiorespiratory endurance of two groups before and after the treatment of the experimental group. The mean values of cardiorespiratory endurance before and after the treatment in the experimental group are 1745.07m and 2033.26m, respectively. The cardiorespiratory endurance ($F=.000$, $P<0.05$) was enhanced significantly in the experimental group. Table 3 also indicates the mean values of cardiorespiratory endurance before and after the treatment in the control group, which are 1768.27m and 1775.86m, respectively. The cardiorespiratory endurance ($F=.634$, $P>0.05$) was not enhanced significantly in the control group.

Discussion

Various training programs of exercises are adopted in order to improve the health-related components of physical fitness ([Kurwale & Gadkari, 2014](#)).

The present study was undertaken in order to investigate the effects of a circuit training program on cardiorespiratory endurance among college students. Cardiorespiratory endurance was improved significantly among the subjects of the experimental group after participation in the 12 weeks circuit training program. There was not any significant difference in the control group in the same period of time, which clearly shows that circuit training has significant effects on cardiorespiratory endurance which is one of the basic components of health-related fitness.

A study was carried out by [Chen, Ismail and Al-Safi \(2016\)](#) in order to find out the effects of resistance training on cardiorespiratory fitness. In the mentioned study, the subjects were male and female, and they were overweight or obese. Their age range was 21 to 55 years. The experimental group was given treatment three sessions per week for eight weeks, and each session of 45 minutes. The cardiorespiratory endurance was measured through the Rockport Fitness Walking Test. In spite of the difference between the two studies with reference to the subjects' age, gender, body composition, duration of the training and the test for measurement of cardiorespiratory endurance, both studies endorse the findings of each other about the effects of circuit training (resistance training) on cardiorespiratory endurance.

Likewise, other Previous studies also clearly show that circuit training significantly improves muscular endurance and cardiorespiratory endurance ([Wong et al., 2008](#)). The significant difference in cardiorespiratory endurance in the current study is also in agreement with studies conducted by ([Goodman, Liu, & Green, 2005](#)), ([McRae et al., 2012](#)), ([Stöggl & Sperlich, 2014](#)) ([Schmitt, Lindner, Reuss-Borst, Holmberg, & Sperlich, 2016](#)), ([Zinner, Sperlich, Born, & Michels, 2016](#)). The mentioned studies were conducted to identify the effects of circuit training upon cardiorespiratory endurance and other health-related components with different intensities, duration of training and sessions per weeks.

Conclusion

It was concluded on the basis of the results of the study that the circuit training program of 12 weeks has a positive effect on cardiorespiratory endurance which is one of the key components of health-related physical fitness.

Limitations of the Study

- 1 The atmospheric temperature was not checked during the treatment.
- 2 Food habits and lifestyle were not part of the study.
- 3 The heredity differences were also beyond the control of the researcher.

Recommendations

The following recommendations are given below on the basis of findings and conclusions

- 1 As it was concluded on the basis of the analysis of data that circuit training improves cardiorespiratory endurance of the college students hence, it is recommended to the government that it may be made part

of their regular schedule so that they (students) may be able to enhance the stated quality of health-related physical fitness.

- 2 The exercises of Circuit Training are simple. They may be made part of the curriculum of Health and Physical education for the students at all level.
- 3 The exercises of Circuit Training may be performed without equipment. These may be adopted by the Government and non-Governmental organizations for the enhancement of cardiorespiratory endurance which is one of the key components of health-related physical fitness.
- 4 It is also recommended to the media to create awareness among the citizens about the benefits of Circuit Training with reference to the improvement of cardiorespiratory endurance.

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