



ISSN: 2456-0057

IJPNPE 2019; 4(1): 2647-2651

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www.journalofsports.com

Received: 05-02-2019

Accepted: 06-04-2019

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A systematic review study of the effects of circuit training on physical fitness components

Sunita Rani**Abstract**

Physical fitness is the ability of our body to perform daily routine tasks with efficiency. Development of physical fitness components such as speed, muscular endurance, agility, Cardio-respiratory endurance, muscular strength and explosive power is the prime concern of coaches and physical educationists. Circuit Training is considered an effective way to enhance fitness efficiency in fitness Industry, sports and military as well. It is the most effective and organized way to develop muscular strength, speed, muscular endurance, co-ordination and agility. 350 research papers were searched using specific keywords in databases, for systematic review, 13 relevant studies were preferred out of them. The studies indicate that the Circuit training have positive effect on co-coordinative abilities, speed, strength, cardio-respiratory endurance. In Circuit Training a 'Circuit fashion' is followed to perform exercises which consists of a number of "Stations". Each participant is instructed to perform an exercise for at least 20 to 45 seconds on each station with 8 to 12 or more repetitions. It is advised to each participant to move quickly from one station to another with a rest period of 15-30 seconds or no rest according to the basic and advanced level of participant, the number of Circuits may vary from 3 to 6. Stations are usually set up at approximately equal distance from one another. It remains more convenient if the signs or name of exercise is displayed on card boards on each station for this purpose. Generally, exercises are performed at a resistance of 40% to 60% of one repetition maximum (1RM), which can be increased as per requirement. The systematic review of selected studies showed that circuit training helps in development physical fitness components including speed, muscular endurance, agility, muscular strength, Cardio-respiratory endurance and explosive power.

Keywords: Circuit training, physical fitness components**Introduction**

Fitness is the basic requirement for healthy lifestyle. We need strength, speed, endurance and flexibility to perform daily routine tasks. Fitness is characterized by the degree to which a person is able to function to perform physical, emotional, mental social and spiritual tasks. Fitness is considered a set of attributes of an individual which may be acquired through training or inherited at the time of birth. A balanced training programme is required to be formulated for remarkable results. Without proper training schedule Physical Fitness is of no use. Kinnet, L.J. *et al.* (1972) ^[8] Different sports need different physical fitness components.

Circuit Training is most effective and organized way of performing physical exercises. It is most challenging task and self-motivating method to develop flexibility, strength, endurance, co-ordination & mobility. In 1953, this method was developed by R.E. Morgan and G.T. Adamson at Leads University (England). The word 'Circuit' in the Circuit training refers to careful and systematic selection of exercises. Circuit exercises must be designed in such a way to fulfil all fitness goals. Morgan, R.E. & Adamson, R.E., (1961) ^[13]. The main aim of Circuit Training is to perform a designed task in a shorter duration so that maximum benefits of physical fitness development can be achieved.

During formulation of Circuit training design all exercises of all the body parts must be included in a circuit. All the muscles must receive proper attention during exercises with the range of 1 to 30 M.R. exercises must be carefully selected in such a way that no consecutive station consists exercises of same muscle groups.

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Methodology

Identification and selection of studies

Scopus, Embase, web of sciences, PubMed, research gate, Google Scholar etc. databases were searched. Words like “Circuit training”, “effect on Physical Fitness components”, “muscular Strength”, “Endurance”, “Agility”, “Speed” etc. were the key terms to identify the literature.

Summary of the included studies

Study- Williams, P.A & Cash, T.F., (2001)

Sample- n=78 (male & female)

▪ All subjects were divided in: -

1. Experimental Group n= 39 (12 Male & 27 Female)
2. Control Group n= 39 (12 Male & 27 Female)

Experimental intervention

- 6 weeks Circuit Weight Training programme was formulated.
- Experimental group was given specific circuit weight training programme.
- Control Group did not participate in any training programme.
- Data were collected using questionnaires i.e Multidimensional Body Self Relation Questionnaire, Physical Self Efficacy Scale and Social Physique Anxiety Scale.

Outcomes

- The study show improvement in satisfaction level and physical self-efficacy.
- Social Physique anxiety were reduced significantly.
- Strength of upper and lower body was improved significantly.

Study-Maiorana, A., *et al.* (2002)^[11]

Sample- n=16 with type-II diabetes (Mean age = 52 +/- 2 Years)

Experimental intervention-

- 8 weeks Circuit Training, Combined Training and Resistance Training Programme were designed for selected patients to Measures Muscular Strength, Body Composition effects on Glycemic Control and Cardio-Respiratory fitness
- Pre and post training data were collected and analyzed statistically at 0.05 level of significance.

Outcomes

- Significant improvement was noticed in ventilatory threshold from 11.8 +/- 0.7 to 13.8 +/- 0.6 ml kg per minute.
- Muscular Strength was improved from 403 +/- 30 to 456 +/- 31 kg ($p < 0.001$).
- Skinfold Measurement was found decreased from 148.7 +/- 11.3 to 141.1 +/- 10.7 mm ($p < 0.05$).
- Body Fat Measurement was significantly decreased from 29.5 +/- 1.0 to 28.7 +/- 1.1 % ($p < 0.05$).
- Waist-Hip ratio was also reduced from 99.2 +/- 1.5 to 97.9 +/- 1.4 ($p < 0.05$).
- Significant improvement was observed in strength and endurance and Peak Oxygen Uptake and fasting food glucose time duration was also decreased.

Study- Gotshalk, L.A., *et al.* (2004)^[7]

Sample- n=11 Male subjects

Experimental intervention-

- 10 weeks training Continuous and Prolonged Circuit Resistance Training and Submaximal & Maximal Treadmill Protocols programme was designed including 10 exercises with 10 repetitions of each exercise.
- 40% Of 1 Repetition Maximum (1RM) were specified for experimentation.
- The main objective of the study to observe the effects of scheduled training protocols on Cardio-respiratory system including oxygen consumption and heart rate response. Pre and Post training. data were collected to observe the effects of training.

Outcomes

1. Due to prolonged Circuit Resistance Training protocol anaerobic capacity was significantly improved but $VO_{2\max}$ was found same i.e. 50%.
2. Significant improvement in $VO_{2\max}$ was due to treadmill running than Circuit resistance training.

Study- Brentano, M.A, *et al.* (2008)^[4]

Sample- n = 28 women (post-menopausal)

All Subjects were divided into 3 groups: -

1. High Intensity Training Group / SGT Group (N= 9)
2. Circuit Training Group / CTG (N= 10)
3. Control Group / CG (N=9)

Experimental intervention-

- Schedule of 24 weeks training was devised to find out the effects of Circuit Training and High Intensity Training on selected variables i.e. Isometric Strength (IS), Maximal Oxygen Uptake ($VO_{2\max}$), Bone Mineral Density (BMD), Upper Limbs Dynamic Strength (ULS), Lower Limbs Dynamic Strength (LLS), Time to Exhaustion (TE) and Muscle Activation of Quadriceps (EMG Quad).
- CT Group was instructed to perform 2-3 sets of exercises with 20-10 reps per set at 45-60% 1RM (1 Repetition Maximum).
- High Intensity Training Group (SGT) was given 2-4 sets of exercises, 20-6 reps per set at 45 to 80 % 1RM (1 Repetition Maximum).
- Control Group was not given any type of training protocol.

Outcomes

- CT Group showed significant improvement in e.g. IS (17.7 %), LLS (42.2 %), $VO_{2\max}$ (18.6 %), EMG Quad (52.4%), TE (16.8 %) and ULS (26.4 %).
- SGT group improvement in IS (32.7%), LLS (39.4 %), $VO_{2\max}$ (22 %), EMG Quad (50.7 %), TE (19.3 %) and ULS (28.7%)
- No significant change was noticed in BMD in Experimental Groups.

The study concluded that It was concluded that Circuit Training and High Intensity Training both have positive effects on muscular strength, endurance, muscular activation, cardio-respiratory fitness on selected subjects.

Study- Chtara, M., *et al.* (2008)^[5].

The study aims to explore the effect of circuit resistance-training sequence and concurrent endurance and on power &

muscular strength development.

Sample- n= 48 students enrolled in physical education (age range= 21.4±1.3 years)

All the subjects were divided in 5 groups

1. No training controls/ C group (n = 9)
2. endurance training/ E group (n = 10)
3. circuit training/ S group (n = 9)
4. Endurance before circuit training in the same session/ E+S Group (n = 10)
5. Circuit before endurance training in the same session/ S+E group (n = 10).

Experimental intervention

- 12 weeks, 2 sessions per week training was formulated, in which for first 6 weeks' resistance-type circuit training was designed to develop strength endurance
- For week 7 to 12 training focused on the development of explosive strength and power.

Outcomes-

- No significant differences were noticed in S+E and E+S groups for all tests.
- Circuit training was found beneficial to enhance strength and power that was significantly greater than the combination of resistance and endurance.

Study- Taskin, H., (2009) [15].

Sample- n= 32 Men; Mean age =23.92 +/- 1.51

- Subjects were categorized into two groups: -

 1. Circuit Training Group (n=16)
 2. Control Group (n=16)

Experimental intervention-

- 10 weeks' schedule of circuit training, 3 days a week with 8 stations was devised for experimentation.
- Purpose of the study was to assess the effects of Circuit Training directed towards motion and action velocity over sprint - agility and anaerobic endurance.
- Circuit training group was instructed to perform selected exercises on 8 stations with 75% maximal heart rate.
- Control group didn't participate in any type of activity.
- Test battery of FIFA Medical Assessment and Research Centre (F-MARC) was used for assessing pre and post training effects of Circuit Training Anaerobic Endurance Sprint-Agility

Outcomes-

- Post training results of anaerobic endurance also show significant improved 30.73 +/- 30.73 +/- 0.50 Seconds at 0.05 significance level.
- Significant changes were observed pre to post training in Circuit Training Group for Sprint-agility 14.47 +/- 0.43 at 0.05 significance level.

Study- Babalola, J.F., (2011) [2].

Sample- n=32 (Men & Women) from racket sports i.e Badminton, Tennis, Squash and Table Tennis players)

Experimental intervention-

- 8 Weeks Circuit Training Programme was devised; twice a week for Experimentation.
- A single group Quasi experimental repeated group design was used to analyse the effects of Circuit Training.

Outcomes

No changes were observed in Agility and Speed

Significant increase was noticed in Muscular Endurance, Cardio-Respiratory Endurance, Arm Muscular Strength, and Flexibility variables.

Study- Mayorga, V. D., *et al.* (2013) [12].

- The objective of the study was to analyze the effects of a circuit training program on muscular and cardiovascular endurance of children in a physical education setting.

Sample- n= 72 Children (age=10-12 years)

All the subjects were divided into: -

- Experimental group (n = 35)
- Control group (n = 37)

Experimental intervention-

- Eight-weeks, twice a week training programme was designed.
- The experimental group was instructed to follow a four-week maintenance program once a week, including one circuit having eight stations.
- The criterion variables were assessed with selected tests i.e. Abdominal muscular endurance through sit-ups (in 30 seconds), muscular endurance of upper limbs with bent arm hang test and cardiovascular endurance using shuttle run test (20-m) to prior to and after the training.

Outcomes

- Muscular and Cardiovascular Endurance was significantly improved of experimental group ($p < 0.05$).
- Control group did not show any change ($p > 0.05$).
- Results of the study indicate that Circuit training was effective to improve and maintain muscular and cardiovascular endurance among school going children.

Study- Al-Haliq, M. (2015) [1].

The study aimed to analyze the effect Circuit training on promotion of physical fitness of Hashemite University students enrolled in Physical Fitness Course.

Sample- n=30 (15 male & 15 female) enrolled in the Physical Fitness Course.

Experimental intervention

- Tests of measuring physical fitness components were used having coefficient of instrument reliability (0.82).
- Pre and post training data were collected for analysis.

Outcomes

The results indicate significant improvement in physical fitness components i.e muscular and cardiovascular endurance of the participants'

Study- Giannaki, C. D., *et al.* (2015) [6].

The study aimed to examine the effects of eight-weeks circuit training programme on physical fitness and body fat of male adolescents.

Sample- n= 39, 16-year old male subjects.

Experimental intervention-

- Eight weeks, two circuit sessions per week were planned during regular PE classes.
- Reading of total body fat was taken using bioelectrical impedance analysis.

- Physical fitness parameters i.e. cardiorespiratory fitness, jumping ability, flexibility, and isometric arm strength were recorded.
- Blood pressure and Resting heart rate were measured with automatic monitor.

Outcomes

- Significant improvement was observed in cardiorespiratory fitness of the circuit training group only ($P < 0.05$).
 - Resting systolic blood pressure and total body fat were significantly lowered in the control group.
- Total body fat % and BMI were significantly increased in post intervention compared to pre intervention period ($P < 0.05$).

Study- Lehnert, M., *et al.* (2015)^[9].

The aim of this study was to find out the effects of circuit training combines with hydraulic resistance machines & weight bearing exercises (CAHCT) on body composition, strength and health-related fitness components of women.

Sample- n=9 women (age 36.2 ± 9.97 ; weight 78.7 ± 13.3 kg & height 168.3 ± 7.8 cm,)

Experimental intervention

- 12 weeks, 3 times a week CAHCT training was formulated for selected subjects to measure the effects on body composition, strength and health-related fitness components of selected women.
- maximum isometric strength for knee flexion/extension was measured by isokinetic dynamometer
- Maximum anaerobic power was measured with Wingate test & strength endurance of abdominal muscles was measured by the partial curl up test.

Outcomes

- No significant improvements were noticed in body composition and isokinetic strength.
- Significant improvements were observed in Wingate test i.e. relative peak and peak power per body weight ($d = 0.58$ & $d = 0.76$ respectively).
- Significant changes were noticed in the results of partial curl-up test ($d = 0.76$).
- Motor fitness component of health-related fitness were significantly improved in regular participant women of strength training
- No changes were observed in body composition.

Study- Malathy, C. & Robert, A. D (2015)^[10].

Sample- n=120 College Women (Age = 17 to 20 years)

- All the subjects were divided into 4 groups: -
1. Physical Exercise Group (n = 30)
 2. Circuit Training Group (n= 30)
 3. Yogic Practice Group (N = 30)
 4. Control Group - (n = 30)

Experimental intervention-

- 12 weeks, 6 days per week, 90 minutes session per day was devised for experimentation.
- Group-1 was given selected Physical Exercise Training.
- Group-2 was given Circuit Training.
- Group-3 was given Yogic Practice Training.
- Group-4 acted as Control Group and didn't participated

in any activity.

Outcomes

- Significant improvement were noticed in Physical Exercise Group, Circuit Training Group and Yogic Practice Group was noticed.
- Effects of Physical Exercises were found better than Circuit Training Group and yogic Practice Group on endurance.
- No significant differences were measured between Yogic Training Group and Control Group on Endurance.

Study- Schmidt, D. *et al.* (2016)^[14]

Sample- n=96 (53 women & 43 Men)

1. All the selected subjects were recreationally active
 2. All the subjects were divided into 3 groups: -
- Group- i. Circuit Training Group (17 women & 15 men) were provided 7 minutes training.
1. Group-ii – Circuit Training Group (15 women & 13 men) were provided 14 minutes training.
 2. Group-iii- Control Group (21 women & 15 men), they didn't provide any training.

Experimental intervention-

- 8 Weeks High intensity Circuit Training Protocol was devised for the study to see the effects on components of physical fitness.
- Experimental Group i was provided 7 Minutes Circuit Training Protocol for 8 Weeks (3 workouts per week).
- Experimental Group ii was instructed to follow 7 Minutes Circuit Training Protocol for first 4 Weeks and 14 minutes training on next 4 Weeks
- Control Group was instructed to maintain normal activity level for 8 Weeks.

Outcomes

1. No significant differences were observed selected variables in pre and post training scores.
2. Repeated analysis showed significant improvement in muscular endurance for both males and females.
3. Muscular strength was found increased in males.
4. Aerobic Capacity was increased in females

Discussion

The systematic review of selected studies shown significant improvement in muscular strength, muscular endurance, cardio-respiratory endurance, speed and agility. It was observed that weight training of 10 to 12 weeks or more have more significant effects on muscular strength, muscular endurance, body composition, flexibility and cardio-respiratory endurance. However, many researchers recommended the Circuit training of more than six weeks including weight for good effects on physical fitness components. It was observed in many studies that intensity and load may vary for desired results. Many researchers recommended 4 to 5 sets including variation in load, decrease the rest period and increasing the load intensity. 12 to 15 repetition or 8 to 12 repetitions with medium load and 5 to 8 repetition with heavy load (as per capacity of individual) for desired results were recommended by the researchers.

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