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Original Article

# Effect of Exercise Intensity on Body Composition in Overweight and Obese Individuals

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## Abstract

**Introduction:** Exercise is an important component of weight loss program. The amount and intensity of exercise required to produce a change in body composition and anthropometric measures are yet to be determined. Traditional steady state exercises performed at moderate intensity have been examined for weight and fat loss. Recently, High intensity exercise done for less duration is emerging and gaining importance. We aimed at investigating the intensity of exercise required to produce a significant change in anthropometric and body composition measurements.

**Materials and methods**: Volunteers, sedentary overweight and obese in the age group of 19-35 years, were randomized into group I (n-35) those performing moderate intensity exercise at 50-74% heart rate maximum reserve for 40 min and group II (n=37) high intensity exercise at 75%-84% of heart rate maximum reserve for 20 min on a bicycle ergometer for a duration of 15 weeks. Anthropometric measures and body composition were determined using skin fold caliper.

**Results:** There was a significant change in the weight, waist hip ratio, skin fold thickness, circumference measures, fat mass, fat percentage, and lean body mass among moderate ($p<0.000$) and high intensity group ($p<0.000$). A significant change in fat mass ($p<0.002$) lean body mass ($p<0.001$) and fat % ($p<0.000$) in the high intensity group compared to moderate intensity group was observed.

**Conclusion:** It is concluded that 15 weeks of exercise at high intensity is more effective in changing the body composition considering the strategy of time commitment in overweight and obese individuals.

## Introduction

Obesity is a major health problem of the developing world and an associated modifiable risk factor for various metabolic disorders. The reason for the increasing trend of obesity in adults is a sedentary life style. It is important to prevent obesity, and exercise is established as an important component of behavioral weight loss program (1). The National program for prevention and control of diabetes and cardiovascular disease suggests moderate to vigorous activity for 5-7 days/week (2). Recognizing exercise protocols that are effective in reducing body fat and feasible to be followed by overweight, sedentary

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individuals are important. Also an effective exercise training depends on exercise intensity and the duration. Different types of exercise are studied for the purpose of weight loss. Traditional steady state low and moderate intensity exercises done over a period of 45-60 min almost every day in a week have resulted in noteworthy change in body weight thereby reducing cardiovascular and metabolic disease risk. Recently, high intensity intermittent exercise (HIT) that involve repeated brief sprinting at an all- out intensity followed immediately by low intensity exercise or rest done for 3-4 days in a week of less duration is gaining importance for the purpose of weight loss and change in body composition. It is also considered as an economical exercise protocol for reducing fat in overweight individuals (3, 4). Studies have examined moderate and high intensity exercise for a change in body composition and have reported conflicting results (5, 6). Limited work have investigated the low volume HIT on people with risk for cardio metabolic disorders and their impending benefits are still uncertain. The optimal amount of exercise necessary to produce a change in body composition is yet to be ascertained and moreover, an exercise program to be operational, must be economical and easy to implement without the necessity of complicated exercise equipment. Therefore, we investigated, a protocol of moderate and high intensity exercise on a simple stationary bicycle ergometer that was required to produce significant change in body composition in overweight and obese individuals.

## Methods

This study was conducted in the Department of Physiology at Indira Gandhi Medical College, Puducherry. Institute ethical committee approval was obtained. Written material explaining the purpose of the study was circulated in the college and hospital, volunteers who wished to participate in the study reported to Physiology department. Informed written consent was taken from volunteers. They were assigned to moderate or high intensity exercise group randomly based on lot method. All procedures followed were according to revised Helsinki Declaration of 2000. Sedentary overweight and obese individuals (BMI≥25) in the age group of 19-35 were included. Exclusion criteria comprised individuals with history of previous surgery, cardiopulmonary and musculo-skeletal disorders, diabetics, hypertensives, and asthmatics. Complete clinical examination, ECG and echocardiogram were taken and fitness obtained from physician before volunteers were involved for the exercise program. 91 volunteers enrolled for the study. 72 of them completed the 15 weeks exercise protocol. 12 opted out due to various reasons not related to the study. There was no injury stated due to the exercise.

**Anthropometric measurements:**

A digital weighing scale that could measure to the nearest 0.1 kg was used to record weight, and height was measured to the nearest centimeter using a stadiometer, in the Frankfurt plane position. Waist circumference was measured in centimeters (cms) midway between the uppermost point on the iliac crest and the lowermost margin of the ribs with the measuring tape parallel to the ground and patient in inspiration. Hip circumference was measured in cms at the maximum circumference of the buttocks at the level of the greater trochanter (7). Waist hip ratio was calculated to be waist circumference in cms divided by hip circumference in cms. Mean of three readings of each measurement was taken for the calculation of WHR. Mid arm, mid-thigh and mid-calf circumference (8) were also measured.

**Measurement of body composition:**

Skin fold measurements were taken from various sites including biceps, triceps, scapular, abdominal, suprailiac, thigh and medial calf sites according to standard procedures using skin fold caliper. All skinfolds were measured to the nearest 1 mm. Mean of 3 readings was recorded at all the sites. All measurements were taken by the same investigator before and after completion of exercise protocol. Durnin's age specific equations (1974) was adopted to calculate body density that was further used in Siri's equation (1961) to determine the total body fat. Fat percentage, fat mass, lean body mass (9) were derived using standardized equations.

**Exercise protocol:**

Subjects were instructed to abstain from caffeine and alcohol at least two days prior to the exercise session and have food two hours prior to the exercise session. During the visit to the laboratory, subjects were well acquainted with the exercise protocol for two weeks and encouraged to get their doubts clarified. Exercise was performed on the bicycle ergometer at the fixed weight to reach the calculated target heart rate using karvonen formula (10).

Exercise protocol for moderate intensity exercise group included performance of Steady state cycling at the heart rate of 50%-74%. of heart rate maximum reserve for a duration of 40 min, 5 days/week (n=37) and High intensity exercise group (n=35) performed 8 sec sprint cycling on bicycle ergometer at the heart rate of 75%-84% of heart rate maximum reserve followed by 12 sec of low intensity cycling for a duration of 20 min, 3 times/week with 5 min of warm up and 5 min of cool down in both the groups.

## Results

Of the 91 volunteers 72 completed the exercise protocol. They were grouped into Group I (n=37) who performed moderate intensity exercise and Group II (n=35) who performed high intensity exercise respectively. The baseline characteristics of the study population, mean age 24.3±6.2, 23.2±5.6 and BMI 29.24±2.59, 29.69±3.2 of the participants in both the groups respectively were similar. Comparison of the anthropometric measurements and body composition before and after exercise in group I is shown in Table I. All the measurements showed a significant change after performance of moderate intensity exercise for a period of 15 weeks. The comparison of the measures before and after completion of exercise protocol in group II showed a significant change as presented in Table II. Fig. 1 depicts the change in the body composition measures between group I and II in which, there was a significant improvement in the lean body mass (p<0.000) and a decrease in fat mass (p=0.002), fat percentage (p<0.000) in both

TABLE I: Comparison of body composition before and after moderate intensity exercise.

| *Measurements* | *Before exercise Mean±SD* | *After exercise Mean±SD* | *P value* |
|---|---|---|---|
| Weight* (kg) | 76.14±10.1 | 72.4±10.3 | 0.000 |
| Waist hip ratio* | 0.81±0.1 | 0.80±0.9 | 0.024 |
| Mid arm circumference* (cm) | 32.4±2.4 | 30.5±2.2 | 0.000 |
| Mid-thigh circumference* (cm) | 56.9±4.3 | 52.86±4.5 | 0.000 |
| Mid-calf circumference* (cm) | 38.68±3.7 | 35.61±3.4 | 0.000 |
| Sum of skin fold measurements (mm)* | 87.61±16.6 | 78.46±14.5 | 0.000 |
| Fat percentage* | 34.2±2.6 | 32.6±2.7 | 0.000 |
| Fat mass* (kg) | 25.9±3.3 | 23.3±3.2 | 0.000 |
| Fat free mass/lean body mass* (kg) | 50.2±7.2 | 49.1±8 | 0.000 |

*p<0.05 significance

TABLE II: Comparison of body composition before and after high intensity exercise.

| *Measurements* | *Before exercise Mean±SD* | *After exercise Mean±SD* | *P value* |
|---|---|---|---|
| Weight* (kg) | 79.1±9.8 | 76.3±9.7 | 0.000 |
| Waist hip ratio* | 0.84±0.7 | 0.80±0.5 | 0.000 |
| Mid arm circumference* (cm) | 32.6±2.5 | 30.2±2.6 | 0.000 |
| Mid-thigh circumference* (cm) | 57.7±4.04 | 53.3±4.3 | 0.000 |
| Mid-calf circumference* (cm) | 38.6±3.2 | 35.4±3.3 | 0.000 |
| Sum of skin fold measurements* (mm) | 86.93±12.08 | 77.93±11.2 | 0.000 |
| Fat percentage* | 34.15±1.9 | 31.05±1.6 | 0.000 |
| Fat mass* (kg) | 27.07±4.06 | 23.7±3.29 | 0.000 |
| Fat free mass/lean body mass* (kg) | 52.05±6.2 | 52.6±6.9 | 0.004 |

*p<0.05 significance

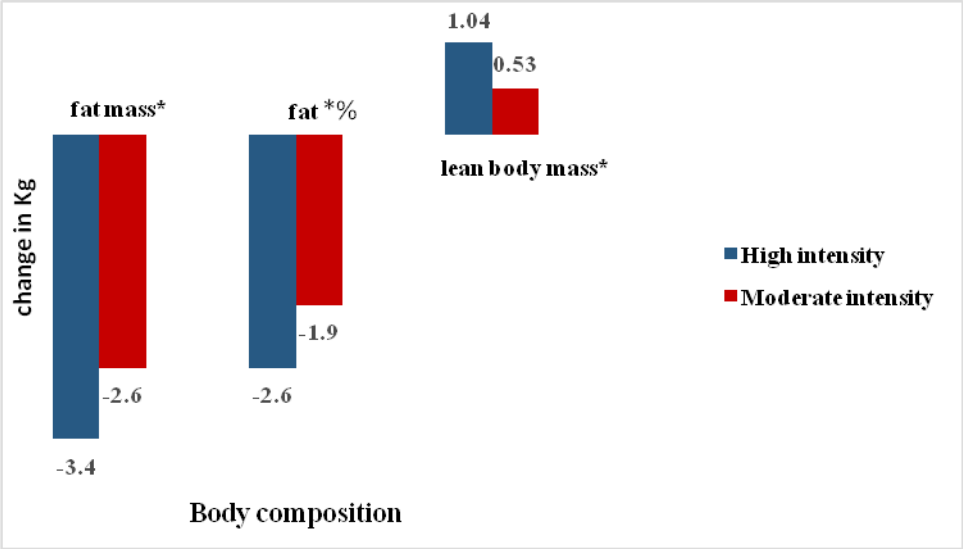


Fig. 1: Comparison of change in body composition between high and moderate intensity exercise groups. *p<0.05 significance

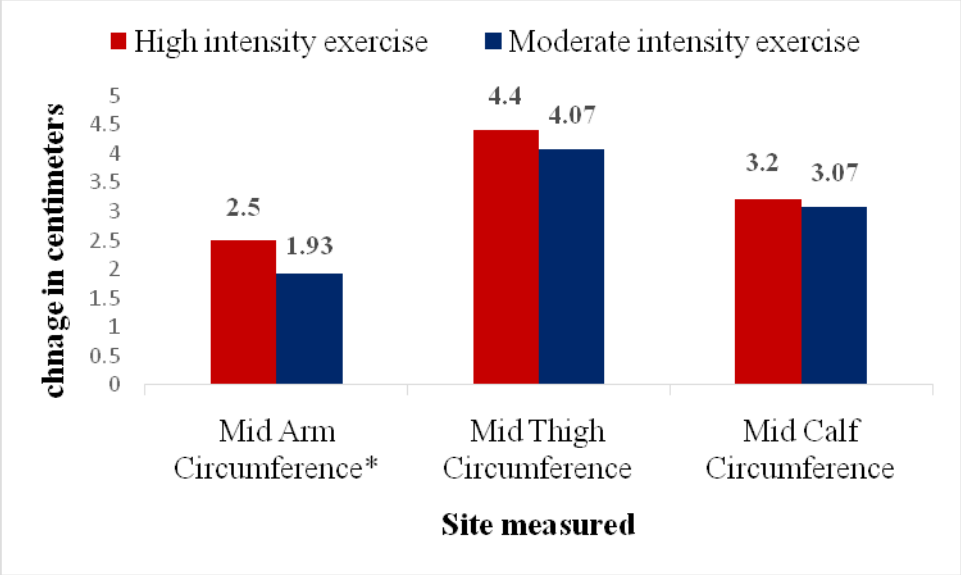


Fig. 2: Comparison of change in circumference between high and moderate intensity exercise groups. *p<0.05 significance

the groups. However, on comparison between group I and Group II the change was statistically significant in group II. Comparing the change in circumference measurements between both the groups significant change in the mid arm circumference (p=0.025) (Fig. 2) in the high intensity group was observed. Comparison of Waist hip ratio with a mean value of 0.80±0.9, 0.80±0.5 in Group I and Group II respectively did not show a statistical significance (p=0.14). Similarly, there was a significant decrease in sum of skin fold measurements of –9.14±4.1, –9.0±2.5 in group I and II respectively. But comparing the change in skin fold measurements between the groups did not show statistical significance.

## Discussion

Body composition refers to the constituents of body-lean mass, fat mass and water, and is not only important for athletes, since an athlete's performance is partially influenced by the proportion of his fat-free mass (FFM) and fat mass (FM), but also for

individuals of all ages, gender and ethnic groups (11). Evaluation of weight alone does not reveal a change in fat or fat free mass. Estimation of body composition using hydrostatic weighing is an intricate procedure. Determination of body composition using anthropometric measures would be a convenient and economical method. Moreover, most validation studies that measures body composition based on anthropometric measures correlates well with the predicted hydrostatic weighing measures (12).

Majann et al (13) and John et al (14) reported that moderate to high doses of exercise in combination with a decrease in energy intake resulted in 8% to 10% reductions in body weight following a 12-month intervention. Participants randomized to vigorous exercise intensity did not have greater weight loss than those randomized to a similar dose of exercise performed at a moderate intensity. Our findings are consistent with these observations. The reduction of weight in moderate and high intensity group was 6.15%, 5.2% respectively. The smaller loss of weight in high intensity group can be explained by a comparable increase in the fat free mass in this group. If the gain in fat free mass is attributed to muscle hypertrophy rather than glycerol stores then resting metabolic rate increases which is favourable for long term weight control.

It is evident from our results, that the fat mass and fat percentage showed a significant decrease in the high compared to the moderate intensity group. These findings are similar to those observed by Knoepfli et al (15) who reported a reduction in absolute body mass, relative total fat mass and an improvement in the waist hip ratio, lean body mass during training in football and runners of 25-45 years males for a period of 12 weeks in the football group relating it to the high intensity exercise. Also Bryner et al (16) compared two types of exercise intensity, running for 40-45 min with a heart rate of 132 beats/min moderate intensity, 163 beats/min high intensity in women in the age group of 18-34 years and observed that there was significant drop in percent body fat while in the moderate intensity group the reduction of was not significant. The authors concluded in favor of high intensity exercise for fat loss.

Controversial results have been reported by Desprest al (17) who examined women who exercised for 90 min at 55% of maximal aerobic power ($VO_2$max) four to five times a week for a period of 14 months. The training program induced a significant mean reduction in body fat mass of 4.6 kg ($p<0.01$), with no change in fat-free mass. The change has been observed in the moderate intensity group but no comparison was made with the high intensity exercise group in this study. Leijssen et al. (5) reported no change in body fat percentage between performing exercise at $VO_2$max 40% (low intensity) and 70% $VO_2$max (high intensity) after 12 weeks of exercise in obese men.

The exercise protocol followed in our study was similar to Trapp et al (18) who conducted an exercise program that included high intensity exercise (n=15) for a duration of 20 min and moderate intensity exercise (n=15) of 40 min duration and observed a 2.5 kg loss of subcutaneous fat in the high intensity group with no change in the moderate intensity group. Fat loss of 50% was attained with less exercise time commitment. Our results are also in favor of high intensity exercise for fat loss. Considering the strategy of time commitment it gives an additional benefit in producing changes in body composition.

The waist hip ratio also significantly reduced in the high intensity group. Van et al (19) also reported that the high intensity group ameliorated waist circumference and the waist-to-hip ratio after intervention. The reasoning probably could be individuals with obesity oxidize more fat during intense physical activity favoring a reduction in WHR (20).

Comparing the change in the circumference between both the groups, a significant decrease in the mid arm circumference was noted in the high intensity group. There was a decrease in the mid- thigh and mid- calf circumference in both the groups but on comparison between the groups it did not show a statistical significance. These findings can again be explained by an increase in the lean body mass in both types of exercise.

The underlying mechanism behind reduction in body adiposity with high intensity exercise is not clear.

Possible mechanisms include factors affecting energy intake (21) and post-exercise energy expenditure (22). Phelan (23) et al observed that, carbohydrate oxidation was significantly greater for the high intensity protocol (75% $VO_2$max) than for the low intensity (50% $VO_2$max) activity and total fat oxidation (exercise plus a 3-h recovery) was greater during the low intensity exercise treatment. However, the calculated fat oxidation was 23.8% higher 3 h after the performance of high compared to low intensity exercise and thus postulated that high intensity exercise allows large amounts of glucose to be utilized and after the exercise training greater contribution of fat oxidation meet the energy requirement. Repeated bouts of high-intensity, intermittent exercise leads to increased lactate and catecholamine levels. The accompanying increase in glycerol levels suggests that fat stores may supply a significant amount of energy during this form of exercise. It is feasible that it creates a "substrate shuttle" whereby there are repeated shifts from anaerobic to aerobic energy sources (24).

In terms of energy expenditure, Ohkawara et al (25) calculated that about 520-550 kcal is expended when performing a moderate intensity exercise session lasting an hour on a stationary bicycle ergometer and, to attain an optimal exercise caloric expenditure of 3,780 kcal per week an individual has to perform approximately seven one hour sessions per week which could be wearisome and make them lose interest in performing regular exercise.

Exercise protocols must be motivating, stress free and realistic to achieve set goals of physical fitness. A strict regimen of exercise along with long duration of performance will be dreary.

The present study aimed at comparing moderate and high intensity exercise protocol required to produce a change in the body anthropometric measures and body composition in overweight and obese individuals. We conclude from our results that both high and moderate intensity exercise produce a significant change in the body composition and circumference measurements. High intensity exercise is more effective and offers an additional advantage of less duration for an improvement in the level of physical fitness and a decrease in body weight compared to moderate intensity exercise protocol of extended duration. Most studies have analysed different intensities of exercise in normal individuals, whereas we have tried evaluating an exercise protocol which would be feasible to be followed by overweight and obese individuals to produce a change in body composition. We believe our results will have strong implications and contribute to weight reduction programs.

## References


1. Bond BJ, Perry AC, Parker L, Robinson A, Burnett K. Dose-response effect of walking exercise on weight loss. How much is enough? *Int J Obes* 2002; 26(11): 1484–1493.
2. National Programme for Prevention and Control of Diabetes, Cardiovascular Disease and Stroke. A manual for medical officer. Developed under the Government of India – WHO Collaborative Programme 2008–2009.
3. Trapp EG, Donald JC, Stephen HB. Metabolic response of trained and untrained women during high-intensity intermittent cycle exercise. *AJP - Regu Physiol* 2007; 293(6): 2370–2375.
4. Boutcher SH. High-intensity intermittent exercise and fat loss. *J Obes* 2011; p. 1–10.
5. Van Aggel Leijssen DP, Saris WH, Wagenmakers, AJ, Senden, JM, Van Baak MA. Effect of exercise training at different intensities on fat metabolism of obese men. *J Appl Physiol* 2002; 92: 1300–1309.
6. Jakicic, JM, Marcus, BH, Gallagher KI, Napolitano M, Lang W. Effect of exercise duration and intensity on weight loss in overweight, sedentary women. *JAMA* 2003; 290: 1323–1330.
7. Singh KD, Dhillon JK, Anupreet A, Gill. BS. Receiver operating characteristic curve analysis of BMI and percentage body fat in type 2 diabetics of Punjab. *Indian J Physiol Pharmacol* 2000; 44(4): 73–80.
8. Heymsfield SB, Nguyen AM, Fong TM, Gallagher D, Pietrobelli A. Body circumferences: clinical implications emerging from a new geometric model. *Nutrition & Metabolism* 2008; 5: 24.
9. Kshitija UP, Anjali SJ. Comparison of $VO_2$max in obese and non-obese young Indian population. *Indian J Physiol Pharmacol* 2011; 55(2): 188–192.
10. Paoli A, Quirico FP, Tatiana M, Giuseppe M, Marco, Giuseppe B, et al. Effects of high-intensity circuit training, low-intensity circuit training and endurance training on blood pressure and lipoproteins in middle-aged overweight men. *Lipids Health Dis* 2013; 12: 131.
11. Rahman R. Effect of moderate and high intensity weight Training on the body composition of overweight men.

*Physical Education and Sport* 2006; vol. 49(2): 93–101.

12. Jackson AS, Pollack ML, Ward A. generalized equations for prediction body density of women. *Med Sci Sports Exerc* 1980; 12(3): 175–182.
13. Majann, G, Mildred C, Jeffrey R, Dan B, Rohin S. Exercise intensity does not effect body composition change in untrained moderately overfat women. Research. *J Am Diet Assoc* 1995; 95: 661–665.
14. John MJ, Bess HM, Kara IG, Melissa N, Wei L. Duration and Intensity on Weight Loss in Overweight, Sedentary Women. *A Randomized Trial JAMA* 2003; 290(10): 1323–1330.
15. Knoepfli LC, Sennhauser C, Toigo M, Boutellier U, Bangsbo J, Krustrup P, et al. Scand J Med Sci Sports 2010. Effects of a 12-week intervention period with football and running for habitually active men with mild hypertension. 2010; 1600–0838.
16. Bryner RW, Toffle RC, Ullrich IH, Yeater RA. The effects of exercise intensity on body composition, weight loss, and dietary composition in women. *Am J Clin Nutr* 1997; 16: 68–73.
17. Després JP, Pouliot MC, Moorjani S, Nadeau A, Tremblay A, Lupien PJ et al. The American journal of physiology. Loss of abdominal fat and metabolic response to exercise training in obese women. 1991; 261(2 Pt 1): E159–E167.
18. Trapp EG, Chisholm DJ, Freund J, Boutcher SH. The effects of high-intensity intermittent exercise training on fat loss and fasting insulin levels of young women. *International Journal of Obesity* (2008) 1–8.
19. Van Aggel-Leijssen DP. Saris WH. Wagenmakers AJ. Hul GB. van Baak MA. The effect or low-intensity exercise training on fat metabolism of obese women. *Obes Res* 2001; 9(2): 86–96.
20. Carlos AF,. Waleria CR, Fett1. Julio SM. Circuit Weight Training vs jogging in Metabolic Risk Factors of Overweight/Obese Women. *Arq Bras Cardiol* 2009; 93(5): 480–486.
21. Rivest S, Richard D. Involvement of corticotropin-releasing factor in the anorexia induced by exercise. *Brain Res Bull* 1990; 25: 169–172.
22. Tremblay A, Simoneau J, Bouchard C. Impact of exercise intensity on body fatness and skeletal muscle metabolism. *Metabolism* 1994; 43: 814–818.
23. Phelan FJ, Reinke E. Harris MA, Melby CL. Postexercise energy expenditure and substrate oxidation in young women resulting from exercise bouts of different intensity. *J Am Coll Nutr* 1997; 16: 140–146.
24. Trapp GE, Donald JC, Stephen HB. Metabolic response of trained and untrained women during high-intensity intermittent cycle exercise. *Am J Physiol Regul Integr Comp Physiol* 2007; 293: R2370–R2375.
25. Ohkawara K, Tanaka S, Miyachi M, Ishikawa-Takata, K, Tabata I, “A dose-response relation between aerobic exercise and visceral fat reduction: systematic review of clinical trials,” *International Journal of Obesity*. vol. 31(12): 1786–1797.