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Original Article

Functional Impact of Interval Training on Muscle Mass and Strength in Obese Adults: An Interventional Trial

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ABSTRACT

Background: Obesity is a burgeoning global health issue, with its prevalence contributing to a spectrum of comorbid conditions, including cardiovascular disease, diabetes, and decreased life expectancy. Traditional exercise regimens have been challenged by the reduced exercise tolerance observed in obese individuals. Interval training has emerged as a promising alternative that may address these concerns by effectively improving body composition and aerobic capacity.

Objective: This study aimed to evaluate the effects of interval training on body composition and aerobic capacity in obese adults. The objective was to determine whether a structured interval training program could lead to significant improvements in these parameters, which are critical indicators of overall health status.

Methods: In a 12-week interventional trial, 30 sedentary obese adults (BMI ≥ 30) underwent interval training sessions three times per week. Body composition was assessed using skinfold thickness and bio-impedance methods, while aerobic capacity was evaluated using lactate threshold testing and the Astrand sub-maximal test. Statistical analysis was performed using SPSS version 25, with significant changes in pre- and post-study values being highlighted.

Results: Post-intervention, participants exhibited a decrease in weight from 79.3 kg to 67.5 kg and a reduction in BMI from 27.6 kg/m² to 24.01 kg/m². Fat percentage also declined from 25.2% to 22.5%. Aerobic capacity improved, with a significant increase in relative oxygen uptake from 38 ml/kg/min to 57 ml/kg/min. Additionally, the mean heart rate during submaximal testing decreased across all exercise intensities, suggesting enhanced cardiovascular efficiency.

Conclusion: Interval training is an effective intervention for improving both body composition and aerobic capacity in obese adults. The study demonstrated significant reductions in body mass and fat percentage, along with improved aerobic efficiency, as evidenced by increased oxygen uptake and reduced heart rates during exercise.

Keywords: Obesity, Interval Training, Body Composition, Aerobic Capacity, Bio-Impedance, Lactate Threshold.

INTRODUCTION

Obesity, recognized as a primary health concern worldwide, has seen a dramatic increase in prevalence, escalating by 74% from 1991 to 2001, with projections indicating that by 2020, nearly half the global population could be classified as overweight or obese (1,2). This rise is largely attributed to sedentary lifestyles and an imbalance between energy intake and expenditure, contributing to a range of health issues including hypertension, type II diabetes mellitus, hypercholesteremia, and cardiovascular disorders (3-5). Interestingly, the increased metabolic demand in obese individuals is often due to the extra load they bear, rather than a deficiency in cardio-respiratory fitness (6,7). Contradictory to this, some studies have indicated that overweight individuals exhibit a significant decrease in heart rate reserve (8-11). Despite the documented effectiveness of aerobic training in enhancing cardiovascular function and managing body weight by reducing body fat (12,13), overweight adults often struggle with such training due to early onset fatigue (6). Endurance training, while beneficial for weight management, does not effectively preserve muscle mass and strength (14-16). This highlights the potential of interval training, which combines aerobic and strength elements, to manage weight and improve functional capacity, muscle mass, and strength in obese adults.

The efficacy of interval training in this context is further supported by the development of specific physiological and anthropometric methods tailored to obese populations, including skinfold body composition analysis, bio-impedance, and progressive exercise testing (14). Norman et al. utilized a cycle ergometer for fitness testing in overweight adults, noting that treadmill testing was impractical for this demographic due to their higher body weight. Their findings revealed that at the lactate threshold level, obese and non-obese adults showed comparable absolute oxygen uptake, but obese adults reached fatigue sooner due to the additional weight they carried (6).

Given the varying data on the effectiveness of different exercise testing methods, our study sought to investigate the impact of interval training on hypercholesteremia, as well as physiological and anthropometric characteristics in obese adults. We aimed to assess the effects of interval training on body composition and functional capacities using suitable physiological and anthropometric methods. Our findings contribute to an evidence-based interval training regimen designed to manage weight and enhance functional capacity, muscle mass, and strength in obese individuals. The study underscores the potential of a well-planned interval training program as a cost-effective, non-hazardous approach to weight management. Additionally, it provides insights into the most effective testing batteries for evaluating anthropometric, physiological, and functional measurements in this population.

MATERIAL AND METHODS

Following the approval of the ethical committee at Riphah International University, Lahore Campus, Pakistan, and registration on ClinicalTrials.gov (NCT04693117), this 12-week interventional trial was conducted between June and December 2019 in the Rehabilitation Clinics of Riphah University Hospital and Anwar Clinic, Lahore, Pakistan. The study included a sample of 30 obese (Body Mass Index, BMI ≥ 30) individuals with a sedentary lifestyle, aged between 30 to 45 years and exhibiting hypercholesteremia. The sample size was determined using the World Health Organization (WHO) sample size calculator. Participants with pre-existing conditions such as hypertension, diabetes, cardiovascular diseases, and systemic diseases were excluded from the study. Recruitment was carried out through voluntary, non-probability consecutive sampling.

Due to the nature of the study, it was designed as a one-group trial, with a notable limitation being its non-randomized structure. Participants, who had not engaged in any interval training program in the six months preceding the study, were selected based on their sedentary lifestyle, defined as engaging in less than 30 minutes of moderate-intensity physical activity on at least three days per week. Informed written consent was obtained from each participant after explaining the study's purpose, procedures, benefits, and potential risks. Regular participation in the interval training program was emphasized to all participants.

The interval training regimen consisted of three weekly sessions over twelve weeks. Each participant received a detailed booklet containing instructions and guidelines about the interval training protocol, which was based on previously established methods (17).

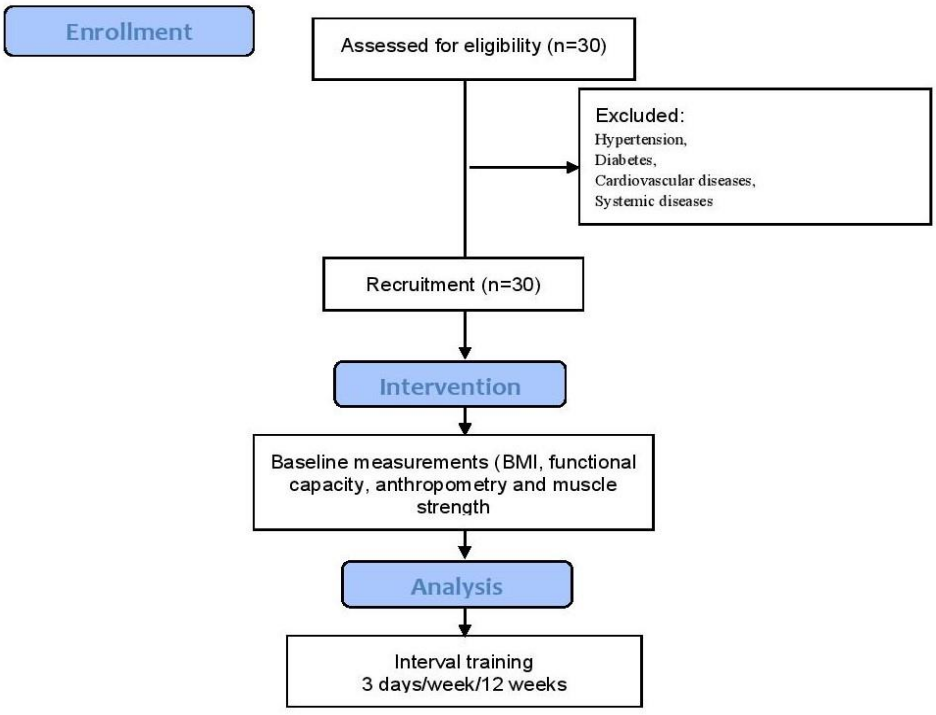

Figure 1 CONSORT Flowchart

The training sessions were conducted on a treadmill, with each participant subjected to the same workload and duration. The intensity of the intervals involved 2 minutes at an estimated power of 85%- 90%, alternating with 3 minutes at a power anaerobic threshold (PTA) of 80% - 85%. Each session lasted 30 minutes, followed by a 5-minute cool-down period of low-speed paddling. All training sessions were supervised by qualified physical therapists.

Data collection entailed pre- and post-study measurements. Anthropometric measurements, including BMI, lean body mass, and body fat percentage, were recorded using the skinfold caliper method and bio-impedance. Functional capacity was assessed based on the lactate threshold level and Astrand submaximal testing,

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adhering to a standardized protocol. Data analysis was conducted using SPSS version 25, ensuring that all statistical evaluations were performed in accordance with the best practices for medical research data analysis. This rigorous methodology ensured that the study's findings would be robust, reliable, and contributory to the field of obesity and exercise science research.

RESULTS

The first figure presents a comparison of anthropometrical values before and after a study. Lean Body Mass decreased from 79.3 kg to 67.5 kg, Body Mass Index (BMI) dropped from 27.6 kg/m² to 24.1 kg/m², and Body Fat Percentage went down from 25.2% to 22.5%. These numerical changes suggest that the intervention applied in the study was effective in reducing body weight and composition metrics among the participants.

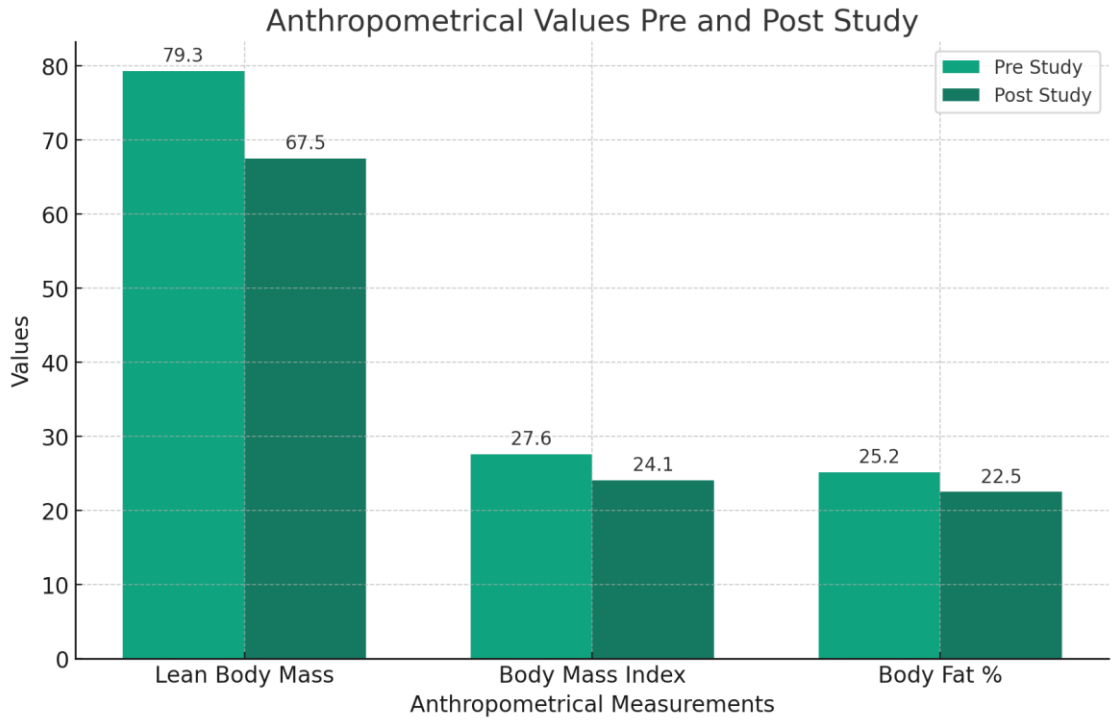

Figure 2 Assessment of body composition by using skinfolds thickness method, n=30

In the Second figure, which plots heart rate and lactate concentration against exercise load, the data illustrates a clear positive correlation between exercise intensity and both heart rate and lactate levels. As the load in kilometers per hour increases, both heart rate (beats per minute) and lactate (millimoles per liter) rise. The heart rate shows a more gradual increase, while the lactate curve suggests a more dramatic rise as the load approaches 18 km/hr, indicating a threshold at which lactate accumulates more rapidly.

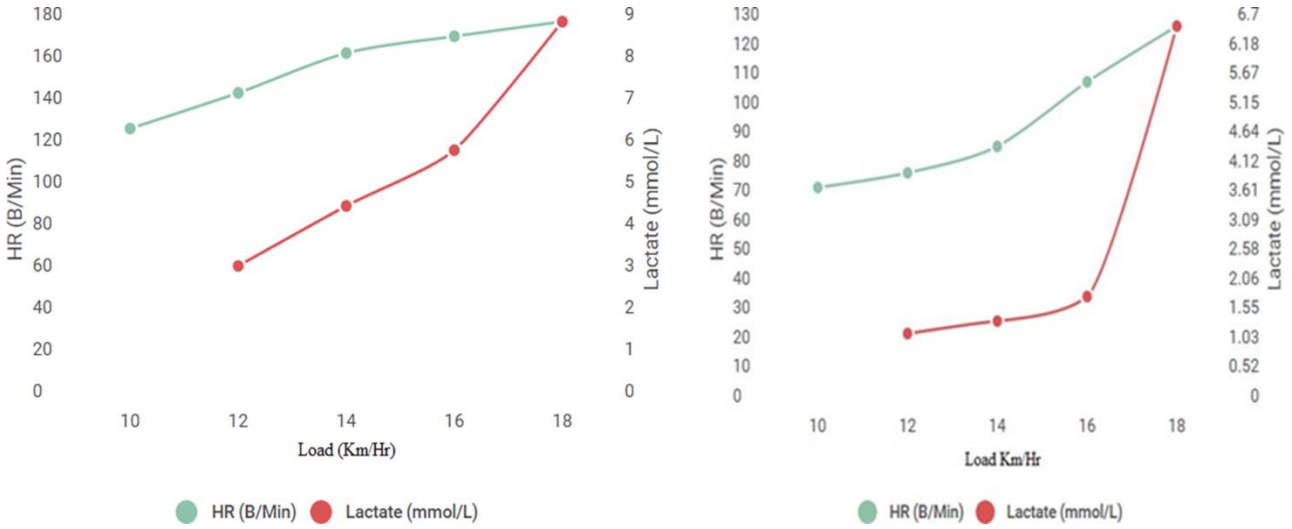

Figure 3 Assessment of aerobic capacity by using Lactate threshold testing, n=30

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Table 1 Assessment of Body Composition Using Bio-Impedance Method (n=30)

Parameter	Baseline Values	Post-Study Values
Weight (kg)	79.3	67.5*
Fat %	25.2	22.5*
Fat Mass (kg)	20.1	17.1
Fat-Free Mass (kg)	56.2	53.9
Muscle Mass (kg)	53.4	55.8
TBW % (Total Body Water)	54.5	55.5
Bone Mass (kg)	2.9	2.92
Metabolic Age (years)	35.3	30.35
Visceral Fat Rating	7.7	6.9
BMI (kg/m²)	27.6	24.01*

The results derived from Table 1 and Table 2 provide a comprehensive overview of the impact of the studied intervention on body composition and aerobic capacity, respectively. In Table 1, the intervention led to a significant reduction in weight, with the average dropping from 79.3 kg to 67.5 kg, denoted by an asterisk to signify statistical significance. Similarly, body fat percentage showed a notable decrease from 25.2% to 22.5%, underscoring the effectiveness of the intervention in reducing fat content. Although fat mass decreased from 20.1 kg to 17.1 kg, changes in fat-free mass and muscle mass were also observed; fat-free mass slightly decreased from 56.2 kg to 53.9 kg, whereas muscle mass increased from 53.4 kg to 55.8 kg, indicating a favorable shift in body composition towards lean tissue accretion. Furthermore, total body water percentage increased marginally from 54.5% to 55.5%, and bone mass remained virtually unchanged, with a slight increase from 2.9 kg to 2.92 kg. Notably, the metabolic age of participants improved from 35.3 years to 30.35 years, and the visceral fat rating decreased from 7.7 to 6.9, suggesting improvements in metabolic health. The Body Mass Index (BMI) also experienced a significant reduction from 27.6 kg/m² to 24.01 kg/m² post-intervention.

Table 2 Assessment of Aerobic Capacity Using Astrand Sub-Maximal Testing (n=30)

Minutes	Load (Watt)	Pre-Study Mean Heart Rate (bpm)	Post-Study Mean Heart Rate (bpm)	Pre-Study Relative Oxygen Uptake (ml/kg/min)	Post-Study Relative Oxygen Uptake (ml/kg/min)
1	100	85	72	Baseline	Baseline
2	100	116	89		
3	100	119	97		
4	100	168	107		
5	100	131	114		
6	100	135	116		
Overall				38	57*

Moving to aerobic capacity in Table 2, at the outset of the exercise test (minute 1), the average heart rate of participants was 85 beats per minute (bpm) in the pre-study phase, which decreased to 72 bpm post-study, indicating an improved cardiac response to exercise. This pattern of reduced heart rate post-intervention was consistent across the entire exercise duration, with pre-study heart rates at 116, 119, 168, 131, and 135 bpm at minutes 2 through 6, respectively, decreasing to 89, 97, 107, 114, and 116 bpm in the corresponding post-study measurements. This trend suggests an enhanced aerobic efficiency as a result of the intervention. Additionally, the overall relative oxygen uptake, an indicator of aerobic fitness, improved significantly (denoted by an asterisk), with pre-study levels at 38 ml/kg/min rising to 57 ml/kg/min post-study, reinforcing the positive impact of the intervention on the participants' cardiovascular fitness.

DISCUSSION

The impact of interval training on the physiological parameters of obese individuals was the focus of this study, which yielded positive outcomes in terms of body composition and overall fitness. The assessment of Body Mass Index through skinfold thickness and bio-impedance techniques provided a dual approach to quantify changes accurately. Moreover, aerobic capacity was evaluated using both lactate threshold testing and the Astrand sub-maximal test, tools that have been corroborated by prior research to effectively measure the functional capacity (14,18,19).

This study reaffirmed the existing literature on the benefits of exercise on body composition, highlighting the efficacy of interval training in enhancing the physical fitness of overweight adults. The use of skinfold calipers, despite being a cost-effective and widely

accessible method, presented certain challenges. Cultural sensitivities regarding bodily exposure and the difficulty in standardizing the technique were noteworthy limitations. The bio-impedance method, while more expedient, underscored the importance of hydration status, which can significantly skew results if not properly controlled.

In evaluating functional capacity, the lactate threshold test was identified as a reliable but costly option that accurately reflected performance capabilities (20). Given that participants were predominantly overweight, the early onset of fatigue was a factor affecting the feasibility of certain exercises, particularly those involving treadmills. The Astrand sub-maximal test, on the other hand, emerged as a cost-effective and less complex alternative for estimating functional capacity (21).

The research demonstrated a considerable improvement in the physical fitness and cardiovascular endurance of overweight individuals following an interval training regimen. Bio-impedance and lactate threshold testing yielded a more comprehensive analysis compared to the skinfold thickness method and the Astrand sub-maximal test. The ability of interval training to enhance functional status and potentially improve the quality of life was evident, thus supporting its use as a beneficial intervention for this population.

Reflecting on the strengths of the study, the significant improvements in body composition and functional capacity are particularly noteworthy. However, the study also acknowledges certain limitations, including the lack of a control group, the small sample size, and the potential for selection bias given the non-randomized design. Furthermore, the reliance on self-reported adherence to the interval training program may have introduced variability in the results.

In light of these findings and the recognized limitations, future research could benefit from a larger, randomized controlled trial to mitigate selection bias and improve the generalizability of the results. Additionally, exploring the long-term sustainability of the observed benefits and the potential psychological impacts of interval training on participants would provide a more holistic understanding of its efficacy.

CONCLUSION

In conclusion, interval training was shown to be an efficacious method for improving body composition and functional capacities in overweight individuals. Bio-impedance and lactate threshold testing were superior in providing detailed insights when compared to the skinfold thickness method and the Astrand sub-maximal test. The implications of interval training are substantial, particularly in improving an individual's functional status and enhancing quality of life without adverse effects. It is recommended that interval training programs be well-structured to maximize cost-effectiveness and to yield optimal outcomes in improving functional capacity.

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