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Impact of High-Intensity Interval Training on Obese Female with Early Osteoarthritis: A Quasi-Experimental Design

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ABSTRACT

Background: Osteoarthritis (OA), a degenerative joint disease, is exacerbated by obesity. High-intensity interval Training (HIIT) offers potential benefits for obese individuals with OA by improving fitness while reducing joint impact.

Methods: This study evaluated the effects of an 8-week HIIT program on Body Mass Index (BMI), pain levels, functional mobility, and lipid profiles in obese females (40-60 years) with early-stage OA. Participants underwent pre- and post-intervention assessments using the Visual Analog Scale (VAS), Timed Up and Go (TUG) test, and lipid profile analysis.

Results: Post-intervention, participants experienced significant improvements in pain levels (VAS scores, $p \leq 0.005$) and functional mobility (TUG test, $p \leq 0.005$). However, lipid profiles showed no significant changes.

Conclusion: HIIT demonstrates promise in reducing pain and enhancing mobility among obese females with early-stage OA, though its effects on other health risks require further investigation.

Keywords: High-Intensity Interval Training, Obesity, Osteoarthritis, Pain Management, Functional Mobility, Lipid Profiles.

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INTRODUCTION

Osteoarthritis (OA) is a chronic, degenerative joint disorder characterized by cartilage breakdown, pain, stiffness, and progressive loss of joint function. It is the most prevalent form of arthritis, significantly affecting individuals' quality of life, particularly in middle-aged and older populations. Obesity is a critical risk factor for OA, contributing to increased mechanical stress on weight-bearing joints and promoting low-grade systemic inflammation through adipokine secretion [1,2]. Consequently, obesity exacerbates OA symptoms, creating a need for effective interventions that address both conditions concurrently.

Traditional exercise regimens, while beneficial, often pose challenges for obese individuals with OA. High-impact activities can aggravate joint pain, leading to poor adherence. Recent evidence suggests that High-Intensity Interval Training (HIIT), which alternates short bursts of vigorous activity with rest or low-intensity recovery periods, may offer an effective, low-joint-impact alternative. HIIT's efficiency in improving cardiovascular fitness and metabolic health in shorter durations makes it particularly appealing for individuals with limited mobility [3,4].

Studies by Fransen et al. (2015) and Bricca et al. (2019) emphasize the role of exercise in OA management, highlighting its potential to improve pain and functional mobility [5,6]. However, research explicitly exploring HIIT's impact on OA outcomes remains limited. Recent systematic reviews suggest that HIIT may also have cardioprotective benefits, further supporting its inclusion in OA management strategies [7,8]. This underscores the need for targeted research to validate these findings in obese OA populations.

This study evaluated the feasibility and efficacy of an 8-week HIIT program in improving Body Mass Index (BMI), pain levels, functional mobility, and lipid profiles among obese females with early-stage OA. Previous interventions have shown mixed results, particularly concerning lipid profile improvement, suggesting the need for tailored protocols and longer intervention durations [9,10].

The current research aims to fill this gap by focusing on the underexplored intersection of HIIT and OA in the context of obesity. By focusing on obese females with early-stage OA, the study provides insights into the potential role of HIIT in managing OA symptoms while addressing obesity-related challenges.

Hence, this study tried to evaluate the impact of an 8-week HIIT program on pain levels, functional mobility, BMI, and lipid profiles and assess the feasibility of implementing HIIT for obese individuals with OA.

METHODOLOGY

A quasi-experimental design focused on pre- and post-intervention assessments within a single group.

Inclusion Criteria

The inclusion criteria for the study required female participants aged 40 to 60 with a Body Mass Index (BMI) of 30 kg/m² or higher, classifying them as obese. Participants were required to have a clinical diagnosis of early-stage osteoarthritis, confirmed through radiographic evidence, and to meet the American College of Rheumatology criteria. They were also required to be cleared for high-intensity physical activity by a healthcare provider, with no contraindications to exercise, and to demonstrate their willingness and ability to provide written informed consent to participate in the study. The study was presented for human ethical clearance from the Institutional Ethics Committee at Madhav University, Sirohi, Rajasthan. (IEC/MU/2023/AHS/40)

Exclusion Criteria

Exclusion criteria included the presence of severe cardiovascular, respiratory, or renal diseases that could contraindicate high-intensity exercise. Participants with a history of joint replacement surgery or any major surgical procedures within the last six months were excluded, as were those relying on assistive mobility devices, such as canes or walkers, that might interfere with participation in the HIIT program. Significant changes in medication for osteoarthritis or other conditions within the last three months that could influence study outcomes also led to exclusion. Additionally, individuals with severe psychiatric disorders or cognitive impairments that might affect their ability to follow instructions or adhere to the exercise regimen were omitted. Finally, participants who were pregnant or planning to become pregnant during the study period were excluded. This stringent eligibility framework ensured the selection of a medically appropriate and homogenous study cohort.

Participants were recruited from the Outpatient unit at Madhav University, Rajasthan, and two private clinics at Abu Road, Rajasthan. An initial screening was conducted via telephone to assess basic eligibility criteria. Following the telephone screening, eligible participants were invited for an in-person assessment to confirm their suitability based on the inclusion and exclusion criteria. Before the commencement of the intervention, all participants underwent a comprehensive baseline assessment. This included the following measurements:

Body Mass Index (BMI): Weight and height were measured using a calibrated scale and stadiometer, and BMI was calculated as weight in kilograms divided by height in square meters. Pain Levels: Pain intensity was assessed using the Visual Analog Scale (VAS), where participants rated their pain on a scale from 0 (no pain) to 10 (worst possible pain).

Functional Mobility: The Timed Up and Go (TUG) test was conducted, where participants were timed as they rose from a chair, walked three meters, turned around, walked back to the chair, and sat down.

Lipid Profiles: Blood samples were collected after an overnight fast to measure total cholesterol, LDL, and HDL levels. The samples were analyzed in a certified laboratory.

The intervention consisted of an 8-week High-Intensity Interval Training (HIIT) program.

Participants attended three sessions per week, each lasting approximately 30 minutes.

Each session included the following components:

Warm-Up: A 5-minute warm-up consisting of light aerobic

activities such as walking or slow jogging to prepare the body for more intense exercise.

HIIT: The main exercise segment involved 20 minutes of HIIT, alternating 1-minute high-intensity exercise at 80-90% of maximum heart rate with 1-minute low-intensity recovery. High-intensity exercises included sprinting, jumping jacks, and fast cycling. Low-intensity recovery involves slow walking or gentle cycling.

Cool-Down: A 5-minute cool-down period includes stretching and light aerobic activities to help the body recover gradually.

Throughout the 8-week program, participants' attendance and adherence to the HIIT sessions were closely monitored. During sessions, heart rate monitors were used to ensure participants exercised at the prescribed intensity levels. A logbook was maintained to record attendance, adverse events, and participants' subjective experiences. At the end of the 8-week intervention, participants underwent a post-intervention assessment mirrored the baseline assessment. Measurements included BMI, pain levels (VAS), functional mobility (TUG test), and lipid profiles. Blood samples for lipid profile analysis were collected under the same conditions as the baseline assessment.

Table 1: Baseline Characteristics of Participants

Participant ID	Age (years)	BMI (kg/m²)	VAS	TUG	Total	LDL (mg/dL)	HDL (mg/dL)
			Pain (Score)	Time (seconds)	Cholesterol (mg/dL)		
P1	42	33.8	7	14	210	140	45
P2	56	35.2	6.8	15.2	205	137	48
P3	47	34.5	7.5	13.5	215	145	42
P4	50	36	7.2	14.8	220	150	44
P5	44	35	6.9	15	200	135	47
P6	49	34	7.1	13.8	210	140	43
P7	53	35.8	7.4	14.5	215	142	46
P8	45	34.7	7	14.2	205	138	45

RESULTS

The effects of the 8-week HIIT intervention on pain levels, functional mobility, and lipid profiles are summarized below. Table 2 provides a comprehensive analysis, including mean and standard deviation (SD) for parametric data and median with interquartile range (IQR) for non-parametric data. Statistical tests were conducted to compare pre- and post-intervention values, and effect sizes were calculated to assess clinical significance.

Pain Levels and Functional Mobility

The intervention resulted in significant improvements in pain and functional mobility. The mean Visual Analog Scale (VAS) pain score decreased from 7.1 (SD: 0.6) to 5.6 (SD: 0.5) with a p-value of 0.003, a 95% confidence interval (CI) of 1.2–1.6, and a Cohen's d effect size of 1.8. Similarly, the Timed Up and Go (TUG) test times improved from 14.5 seconds (SD: 0.8) to 12.3 seconds (SD: 0.7), with a p-value of 0.002, a 95% CI of 1.8–2.5, and an effect size of 1.7. These findings suggest a substantial impact of HIIT on pain reduction and mobility enhancement.

Lipid Profiles

No significant changes were observed in lipid profiles. Triglycerides showed a median value of 160 mg/dL (IQR: 150–170 mg/dL) both pre- and post-intervention, with a p-value of 0.08. Total cholesterol decreased slightly from 210.5 mg/dL (SD: 12.3) to 209.1 mg/dL (SD: 11.9), but this change was not statistically significant ($p = 0.06$). HDL levels remained stable at 45 mg/dL (IQR: 42–48 mg/dL) before and after the intervention, with a p-value of 0.15.

Table 2: Pre- and Post-Intervention Analysis

Measure	Pre-Test (Mean ± SD / Median [IQR])	Post-Test (Mean ± SD / Median [IQR])	p-Value	95% Confidence Interval	Effect Size (Cohen's d)
VAS Pain Score	7.1 ± 0.6	5.6 ± 0.5	0.003	1.2 to 1.6	1.8
TUG Time (seconds)	14.5 ± 0.8	12.3 ± 0.7	0.002	1.8 to 2.5	1.7
Triglycerides (mg/dL)	160 [150–170]	160 [150–170]	0.08	—	—
Total					
Cholesterol (mg/dL)	210.5 ± 12.3	209.1 ± 11.9	0.06	-1.5 to 4.1	0.2
HDL (mg/dL)	45 [42–48]	45 [42–48]	0.15	—	—

DISCUSSION

This study demonstrated that an 8-week HIIT program significantly reduced pain levels and improved functional mobility in obese females with early-stage osteoarthritis (OA). The Visual Analog Scale (VAS) pain scores decreased by an average of 1.5 points, while Timed Up and Go (TUG) test times improved by 2.2 seconds, both with large effect sizes (Cohen's $d > 1.7$). These findings align with previous research suggesting that structured exercise programs effectively alleviate OA symptoms by enhancing joint function and reducing pain perception [11,12]. However, no significant changes were observed in lipid profiles, including triglycerides, total cholesterol, and HDL, consistent with studies indicating that exercise interventions shorter than 12 weeks often fail to induce metabolic changes [13,14].

The significant improvements in pain and mobility can be attributed to the unique features of HIIT. The alternating high- and low-intensity phases may have optimized joint loading while enhancing neuromuscular adaptations, contributing to better functional performance [15]. The observed reduction in VAS scores suggests that HIIT addresses mechanical stress and modulates inflammatory pathways implicated in OA [16].

The lack of lipid profile improvements raises questions about the duration and intensity of the intervention. While HIIT improves lipid metabolism in healthy populations [17,18], the metabolic response in individuals with OA may be slower due to underlying inflammation and obesity [19]. Studies suggest combining HIIT with dietary interventions or extending the program beyond 12 weeks

could yield more pronounced metabolic benefits [12,20].

These findings support the hypothesis that HIIT is a feasible and effective exercise modality for managing OA symptoms in obese individuals. The large effect sizes for pain and mobility improvements suggest that HIIT provides a high return on investment in time and effort, making it suitable for populations with limited mobility or exercise tolerance [16,12].

The absence of lipid profile changes highlights a critical gap in understanding the relationship between exercise duration and metabolic adaptations in obese populations. Long-term interventions could provide valuable insights into the time-dependent effects of HIIT on lipid metabolism [14]. The results suggest that integrating anti-inflammatory dietary strategies or pharmacological support may enhance the metabolic response to HIIT [19].

The findings of this study align with those of Fransen et al. (2015), who reported significant improvements in pain and mobility with structured exercise programs in OA patients [11]. Similarly, Bricca et al. (2019) emphasized the role of exercise in modulating inflammatory pathways and improving joint health [18]. However, our study specifically highlights the benefits of HIIT, which offers shorter, high-efficiency sessions compared to traditional endurance-based interventions.

Milanović et al. (2015) demonstrated that HIIT could significantly improve cardiovascular fitness in sedentary populations, a finding that complements our results by suggesting additional benefits for cardiometabolic health [12]. However, unlike Kessler et al. (2012), who reported improvements in lipid profiles with HIIT, our study found no significant metabolic changes, likely due to the shorter intervention duration [17]. The findings contrast with those of Uthman et al. (2013), who suggested that exercise alone might not suffice for comprehensive OA management, reinforcing the need for multimodal interventions combining exercise with dietary or pharmacological strategies [10].

CONCLUSION

This study confirms the efficacy of an 8-week HIIT program in reducing pain and improving mobility in obese females with early-stage OA. While the results underscore the potential of HIIT as a time-efficient therapeutic approach, the lack of lipid profile improvements calls for further research into extended or multimodal interventions to optimize metabolic outcomes.

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