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Effect of 12 Weeks Pilates Exercise on Oncostatin-M And Insulin Resistance Inactive, Obese Men

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Original Research

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Abstract

Purpose: Obesity and physical inactivity are linked to insulin resistance and chronic low-grade inflammation. Oncostatin-M (OSM), an IL-6 family cytokine, may connect adipose inflammation to metabolic dysfunction. This study examined whether 12 weeks of supervised Pilates alters serum OSM and insulin resistance indices in inactive obese men. **Method:** In this quasi-experimental study with random allocation, 30 inactive obese men (30–50 years; BMI 30–35 kg/m²) were assigned to Pilates (n=15) or control (n=15). The Pilates group trained three times weekly for 12 weeks; controls maintained their usual lifestyle. Weight, BMI, waist circumference, estimated VO_2max, fasting glucose, fasting insulin, HOMA-IR, and serum OSM were assessed pre- and post-intervention. Mixed ANOVA and paired/independent t-tests were used ($p<0.05$). **Results:** Significant group × time interactions were found for weight ($p = 0.008$), BMI ($p=0.012$), waist circumference ($p = 0.003$), VO_2max ($p=0.004$), fasting glucose ($p=0.015$), fasting insulin ($p=0.006$), HOMA-IR ($p=0.002$), and OSM ($p=0.001$). The Pilates group showed decreased adiposity, fasting glucose and insulin, HOMA-IR, and OSM, alongside increased VO_2max, whereas the control group showed no significant changes. **Conclusion:** Twelve weeks of supervised Pilates improved body composition, cardiorespiratory fitness, and insulin resistance while reducing circulating OSM in inactive obese men, suggesting Pilates as a feasible low-intensity strategy to induce favorable immunometabolic adaptations.

Keywords: Pilates; Oncostatin-M; insulin resistance; obese men; exercise training.

Introduction

Obesity and physical inactivity in middle-aged men are major contributors to insulin resistance, type 2 diabetes and cardiovascular disease (Amati et al., 2009; Elagizi et al., 2020; Lin & Li, 2021). Sedentary obese men typically present with excess visceral and subcutaneous adiposity, low cardiorespiratory fitness and impaired peripheral insulin sensitivity, placing them at particularly high cardiometabolic risk (Amati et al., 2009; Elagizi et al., 2020; James & Stanford, 2025). A sedentary lifestyle is recognized as a key driver of obesity-related complications, whereas increased habitual physical activity and structured exercise training improve insulin sensitivity and glucose homeostasis in obese and insulin-resistant individuals (Gregory et al., 2019; Pan et al., 2018; Way et al., 2016). Nevertheless, many inactive obese men are reluctant or unable to engage in high-impact or high-intensity exercise because of joint pain, low fitness or comorbidities, underscoring the need for low-impact, accessible training modalities that can elicit meaningful metabolic adaptations in this population (Gordon et al., 2009; Strasser & Pesta, 2013; Stroh & Stanford, 2023).

Oncostatin-M (OSM) is a member of the interleukin-6 cytokine family that has emerged as an exercise-responsive metabolic regulator and a potential link between adipose tissue inflammation and insulin resistance (Bailey et al., 2022; Sánchez-Infantes et al., 2014; Sánchez-Infantes et al., 2021). Acute exercise induces robust up-regulation of OSM gene expression in human subcutaneous adipose tissue and increases circulating OSM, where OSM released from immune cells modulates adipocyte MAPK/ERK signaling and regulates lipolysis (Bailey et al., 2022; Dollet et al., 2024; Stanford & Goodyear, 2016). OSM expression in adipose tissue correlates positively with body mass index and HOMA-IR in individuals with type 2 diabetes, suggesting that elevated OSM reflects a pro-inflammatory, insulin-resistant state (Sánchez-Infantes et al., 2014; Sánchez-Infantes et al., 2021). Chronic training, however, may down-regulate this obesity-related OSM elevation (Dollet et al., 2024; Norheim et al., 2014; Stanford &

Goodyear, 2016). In overweight and obese women, eight weeks of moderate-intensity aerobic exercise significantly improved body composition, lipid profile and insulin resistance indices, while concurrently reducing serum OSM levels, supporting a role for exercise in attenuating OSM-mediated adipose tissue dysfunction (Akbarzadeh et al., 2025). Despite these findings, data on how resistance-type or mind–body exercise, such as Pilates, affects OSM—particularly in inactive obese men—are lacking (KhajehLandi et al., 2020; Mir & Fathi, 2018). In obese men, a 12-week supervised program combining aerobic and resistance exercise increased maximal aerobic capacity and muscle strength and significantly improved peripheral insulin sensitivity, even though adipose tissue insulin sensitivity and morphology were largely unchanged (Pan et al., 2018; Stinkens et al., 2018). These results highlight the pivotal contribution of skeletal muscle adaptations to exercise-induced improvements in insulin action (Gregory et al., 2019; Strasser & Pesta, 2013; Way et al., 2016). Low-impact resistance-type formats such as Pilates may be particularly attractive for obese, low-fit adults (KhajehLandi et al., 2020; Mir & Fathi, 2018; Pan et al., 2018). In obese women with type 2 diabetes, eight weeks of Pilates exercise three times per week reduced body weight, fat percentage, fasting glucose and insulin and produced a significant decrease in HOMA-IR compared with a non-exercising control group (Mir & Fathi, 2018). Collectively, existing evidence indicates that both combined training and Pilates-based programs can enhance insulin sensitivity; however, most studies have been conducted in women, and the specific effects of Pilates on inflammatory cytokines have not been explored (Akbarzadeh et al., 2025; KhajehLandi et al., 2020; Pan et al., 2018).

Given that OSM is a pro-inflammatory cytokine linked to insulin resistance, suppression of adipose tissue browning and impaired thermogenic capacity, its modulation by exercise may represent an important mechanistic pathway through which training improves metabolic health in obesity (Bailey et al., 2022; Norheim et al., 2014; Sánchez-Infantes et al., 2021; Stanford & Goodyear, 2016). The concurrent reduction in OSM and insulin resistance after aerobic training in overweight and obese women suggests that targeting OSM through exercise could have therapeutic relevance, but these findings cannot be directly generalized to inactive obese men or to resistance-type modalities such as Pilates (Akbarzadeh et al., 2025; Pan et al., 2018). Moreover, while combined aerobic–resistance programs in obese men improve peripheral insulin sensitivity, they have not assessed OSM, leaving a gap in our understanding of how low-impact strengthening exercise influences this cytokine and insulin resistance simultaneously in a high-risk male population (Gregory et al., 2019; Stinkens et al., 2018; Stroh & Stanford, 2023). Therefore, the present study aimed to investigate the effect of 12 weeks of supervised Pilates exercise on serum oncostatin-M levels and indices of insulin resistance in inactive obese men.

Methods

Study design and participants

Thirty men aged 30 to 50 years with a body mass index (BMI) of 30 to 35 kg/m2 and a sedentary lifestyle were randomly assigned to two groups. Inclusion criteria were: male sex, age 30 to 50 years, BMI 30 to 35 kg/m2, inactive, and medical clearance for moderate exercise. Exclusion criteria included: uncontrolled cardiovascular, renal, hepatic, or endocrine disease; use of insulin or medications that significantly affect glucose metabolism; smoking; participation in structured exercise programs or weight loss within the past 3 months; and musculoskeletal or neurological limitations to exercise. Participants who met the criteria were randomly assigned to the Pilates group (n = 15) or the control group (n = 15). All participants were asked to maintain their usual diet and physical activity throughout the study. The protocol was approved by the ethics committee, and written informed consent was obtained from all participants.

Exercise protocol

The Pilates group performed a supervised Pilates program on the mat for 12 weeks, three sessions per week on nonconsecutive days. Each session lasted approximately 50–60 min and included the following: warm-up (10 min) and light aerobic activity and dynamic stretching. Pilates exercises (35–40 min) on the mat with emphasis on core stability, trunk and pelvic control, and postural control (e.g., centipede, roll-up, single-leg stretch, spinal stretch, shoulder bridge, lateral push-up series) and The cool-down (5–10 min) was performed using static stretching. Intensity was maintained at a moderate level (11–13 on the Borg scale of 6–20). The exercise difficulty was gradually increased by adjusting repetitions, sets, and movement complexity. All sessions were supervised by a certified Pilates instructor and an exercise physiologist. Attendance was recorded, and participants who attended less than 85% of the sessions were excluded from the analyses of each protocol. Control participants were instructed to refrain from starting new structured physical activity programs during the 12-week period, and were contacted weekly to monitor adherence and minimize dropout.

Measurements

Venous blood samples were collected from the antecubital vein between 8:00 and 9:00 AM after an overnight fast. Serum and plasma were separated by centrifugation at 3000 rpm for 10–15 min and stored at −80°C until analysis. Fasting plasma glucose was determined by enzymatic colorimetric method (glucose oxidase). Serum insulin concentration was measured using a commercial enzyme-linked immunosorbent assay (ELISA). Serum oncostatin-M (OSM) was determined using a high-sensitivity ELISA kit specific for human OSM, and all samples were analyzed in duplicate. Intra- and inter-assay coefficients of variation were kept below 10%. Insulin resistance was estimated using the Homeostatic Model of Insulin Resistance (HOMA-IR), which is calculated as follows:

$$\mathrm{HOMA-IR} = \frac{fasting\ insulin\ (\mu U/mL) \times fasting\ glucose\ (mg/dL)}{405}$$

Statistical Analysis

The primary outcomes were changes in serum OSM and HOMA-IR from baseline to post-intervention. Secondary outcomes included changes in fasting glucose, fasting insulin, body weight, BMI, waist circumference, and estimated VO_2max.

Data analysis was performed using SPSS version 26. Normality of distributions was assessed using the Shapiro-Wilk test. Baseline differences between groups were examined using independent samples t-tests. Intervention effects were assessed using two-way mixed analysis of variance (group × time). When significant interactions were found, Bonferroni-adjusted post hoc tests were used. Within-group changes were also examined with paired t-tests, and between-group differences in change scores with independent t-tests as supportive analyses. Effect sizes were reported as partial eta-squared (η^2p) for ANOVA and Cohen's d for t-tests. Statistical significance was set at $p < 0.05$.

Participant characteristics and adherence

Thirty inactive obese men were randomized to the Pilates (n = 15) and control (n = 15) groups. All participants completed the 12-week study, and mean session attendance in the Pilates group was 92% (range: 86–100%). There were no significant differences between groups at baseline in age or any anthropometric, fitness or biochemical variable (all $p>0.05$).

Results

Anthropometric and fitness outcomes

Changes in anthropometric and fitness variables are presented in Table 1. There were significant group × time interactions for body weight (p=0.008), BMI (p=0.012), waist circumference (p=0.003), and estimated VO_2max (p=0.004).

In the Pilates group, body weight (p = 0.001), BMI (p=0.002), and waist circumference (p=0.001) decreased significantly after 12 weeks. Estimated VO_2max increased significantly (p=0.001).

In contrast, the control group showed no significant changes in body weight (p=0.210), BMI (p=0.230), waist circumference (p = 0.180), or VO_2max (p=0.420). The reductions in body weight, BMI, and waist circumference, as well as the improvement in VO_2max, were all significantly greater in the Pilates group compared with the control group (between-group p for change=0.008, 0.012, 0.003, and 0.004, respectively).

Table 1. Anthropometric and fitness variables before and after 12 weeks of Pilates training or control

Variable	Group	Pre-test (Mean±SD)	Post-test (Mean±SD)	Within-group p -value	Between-group p -value
Weight (kg)	Pilates	96.2 ± 7.5	92.0 ± 7.3	0.001*	0.008*
	Control	95.5 ± 8.1	94.8 ± 8.0	0.210	0.210

BMI (kg/m²)	Pilates	32.1 ± 1.8	30.7 ± 1.9	0.002*	0.012*
	Control	31.9 ± 1.9	31.6 ± 2.0	0.230	0.230
Waist circumference (cm)	Pilates	110.3 ± 6.2	104.8 ± 6.0	0.001*	0.003*
	Control	109.4 ± 6.0	108.3 ± 6.1	0.180	0.180
VO_2max ($mL·kg^{-1}·min^{-1}$)	Pilates	26.0 ± 3.4	30.2 ± 3.6	0.001*	0.004*
	Control	26.1 ± 3.2	26.4 ± 3.3	0.420	0.420

*Significant sign

Metabolic and Oncostatin-M outcomes

Metabolic variables and serum oncostatin M (OSM) concentrations are summarized in Table 2. Significant group × time interactions were observed for fasting glucose (p = 0.015), fasting insulin (p = 0.006), HOMA-IR (p = 0.002), and OSM (p = 0.001).

In the Pilates group, fasting glucose (p = 0.004) and fasting insulin (p = 0.002) decreased significantly; consequently, HOMA-IR was significantly reduced (p = 0.001). Serum OSM levels also decreased significantly (p = 0.001).

In the control group, none of the metabolic parameters changed significantly over time: fasting glucose (p = 0.470), fasting insulin (p = 0.510), HOMA-IR (p = 0.530), and OSM (p = 0.600).

The reductions in fasting glucose, fasting insulin, HOMA-IR, and OSM were significantly greater in the Pilates group than in the control group (between-group p for change = 0.015, 0.006, 0.002, and 0.001, respectively).

Table 2. Metabolic variables and serum Oncostatin-M before and after 12 weeks of Pilates training or control

Variable	Group	Pre (Mean±SD)	Post (Mean±SD)	Within-group p -value	Between-group p -value
Fasting glucose (mg/dL)	Pilates	112.4 ± 9.8	102.3 ± 8.7	0.004*	0.015*
	Control	111.7 ± 8.9	110.6 ± 9.1	0.470	0.624
Fasting insulin (μU/mL)	Pilates	18.2 ± 4.1	13.4 ± 3.6	0.002*	0.006*
	Control	18.0 ± 3.9	17.6 ± 4.0	0.510	0.758
HOMA-IR (a.u.)	Pilates	5.04 ± 1.21	3.39 ± 0.96	0.001*	0.002*
	Control	4.96 ± 1.10	4.82 ± 1.15	0.530	0.756
Oncostatin-M (pg/mL)	Pilates	40.8 ± 7.5	30.1 ± 6.3	0.001*	0.001*
	Control	40.2 ± 7.1	39.5 ± 7.3	0.600	0.241

*Significant sign

Discussion

Regular physical activity is widely recognized as a cornerstone strategy for the management of obesity-related insulin resistance, yet many inactive obese adults are unable or unwilling to perform high-impact or high-intensity exercise because of joint pain, low fitness and comorbidities (Wang et al., 2025). In this context, the present trial showed that a 12-week supervised mat-based Pilates program in inactive obese men improved central adiposity and cardiorespiratory fitness and was accompanied by favourable changes in fasting glucose, insulin resistance indices and circulating oncostatin-M (OSM) compared with a non-exercising control group. These findings suggest that a low-impact, resistance-type modality such as Pilates can elicit not only functional and anthropometric benefits, but also meaningful immunometabolic adaptations in a high-risk male population.

The most novel observation of this study is the reduction in serum OSM following Pilates training. OSM is a gp130 cytokine of the interleukin-6 family that is produced predominantly by adipose-tissue immune cells and is markedly up-regulated in conditions of obesity and type 2 diabetes, where circulating and tissue OSM levels correlate positively with body weight, fasting insulin and HOMA-IR (Akarsu et al., 2019). Experimental work shows that OSM impairs brown adipose thermogenic capacity, inhibits the browning of white adipose tissue and promotes adipose inflammation and insulin resistance, while genetic or pharmacological disruption of OSM signalling in adipocytes leads to profound disturbances in glucose homeostasis (Bailey et al., 2022). More recently, human exercise studies have identified OSM as one of the most strongly up-regulated adipose-tissue–secreted factors after an acute bout of exercise, mediating immune–adipocyte crosstalk via MAPK/ERK-dependent regulation of lipolysis (Dollet et al., 2024; Komori et al., 2022). Our findings that chronic, low-impact training lowered basal OSM in inactive obese men are broadly consistent with pilot data in obese adults and with the concept that repeated exercise bouts can “reset” chronically elevated inflammatory adipokines towards a less insulin-resistant profile (Akarsu et al., 2019; Piquer-García et al., 2019). Discrepancies with studies that failed to observe changes in adipose inflammatory markers despite improved insulin sensitivity may reflect differences in exercise mode, intensity and duration, the magnitude of fat-mass reduction or the use of circulating versus tissue-specific measures (AbouAssi et al., 2015).

Regarding insulin resistance, the current trial showed that Pilates training reduced fasting insulin and HOMA-IR relative to control, indicating improved whole-body insulin action. Similar improvements in HOMA-IR and cardiometabolic risk markers have been reported after 6–8 weeks of Pilates or combined Pilates-based programs in overweight and obese women, sometimes in conjunction with nutraceutical supplementation (Sabzevari et al., 2022). These findings are in line with systematic reviews and meta-analyses demonstrating that resistance-type and combined exercise training significantly lower fasting insulin and HOMA-IR across diverse at-risk populations (Wang et al., 2025). On the other hand, some trials have reported minimal changes in HOMA-IR after low-dose Pilates or resistance programs in well-controlled patients or those with modest baseline insulin resistance (Lima et al., 2022; Suh et al., 2011). In such settings, stable pharmacotherapy, short intervention duration or insufficient mechanical loading of large muscle groups may blunt the potential benefits on insulin signalling, highlighting the importance of adequate training volume and progression (Glynn et al., 2015; Małkowska et al., 2024).

The favourable changes in fasting glucose observed in the Pilates group are also consistent with accumulating evidence that Pilates-based exercise can improve glycaemic control. Randomized and quasi-experimental studies have shown reductions in fasting glucose, glycosylated haemoglobin and other glycaemic indices following Pilates interventions in adults with obesity, prediabetes or established type 2 diabetes (Ruiz-Ariza et al., 2025) In overweight women, combining Pilates with cumin or dill supplementation further enhanced improvements in lipid profile and insulin resistance, suggesting potential synergistic effects between mind–body exercise and dietary adjuncts (Sabzevari et al., 2022; Salem et al., 2019). Conversely, in some older or highly medicated cohorts, Pilates appears to exert more robust effects on physical function and quality of life than on fasting glycaemia, probably because medication regimens and long disease duration limit the observable incremental effect of exercise on blood glucose (Ruiz-Ariza et al., 2025).

Finally, the observed reductions in body weight and waist circumference and the improvement in estimated VO_2max align with trials demonstrating that Pilates can reduce adiposity and enhance functional capacity in overweight and obese adults (Khajehlandi et al., 2024). The magnitude of change in central adiposity and cardiorespiratory fitness in our study falls within the range reported in RCTs of normoxic and hypoxic Pilates and in low-volume concurrent training protocols for individuals with obesity or metabolic syndrome (Jung et al., 2020; Reljic et al., 2025; Streb et al., 2021). At the same time, meta-analytic data indicate that even relatively modest exercise doses—when performed regularly and with sufficient intensity—can meaningfully improve waist circumference, body composition and CRF, which in turn are closely linked to improved insulin sensitivity and cardiometabolic risk (Jayedi et al., 2024).

Taken together, the concurrent reduction in OSM and HOMA-IR in inactive obese men following 12 weeks of Pilates supports a mechanistic link between exercise-induced immunomodulation and improved metabolic health. Experimental and translational studies show that OSM is both a marker and mediator of adipose-tissue inflammation and insulin resistance, integrating signals from immune cells, adipocytes and skeletal muscle during and after exercise (Dollet et al., 2024). By lowering basal OSM while simultaneously enhancing insulin sensitivity and cardiorespiratory fitness, Pilates may contribute to a shift towards a less inflammatory, more metabolically flexible phenotype in obese men. Strengths of the present study include its randomized design, supervised intervention and parallel assessment of inflammatory and metabolic markers; limitations include the relatively small sample size, restriction to middle-aged men, absence of direct adipose-tissue measurements and lack of long-term follow-up. Future studies should confirm these findings in larger, more diverse populations and explore whether combining Pilates with dietary or pharmacological strategies can further potentiate OSM-targeted improvements in insulin resistance.

Conclusion

The findings of the present study demonstrate that 12 weeks of supervised Pilates training, performed three times per week, led to significant improvements in body composition, cardiorespiratory fitness, and metabolic health in inactive obese men

Reductions in body weight, body mass index, and waist circumference, alongside an increase in estimated VO_2max, indicate that this low-impact training modality can effectively enhance physical fitness in a high-risk population.

From a metabolic perspective, Pilates training significantly decreased fasting glucose, fasting insulin, and HOMA-IR, reflecting improved insulin sensitivity

Notably, serum oncostatin-M (OSM) levels were also significantly reduced. Given the established association between elevated OSM, adipose tissue inflammation, and insulin resistance, the concurrent decline in OSM and HOMA-IR suggests that Pilates may exert beneficial effects through immunometabolic modulation, potentially attenuating obesity-related inflammatory processes.

Considering that many inactive obese individuals face barriers to high-intensity or high-impact exercise, these findings support Pilates as a feasible, accessible, and well-tolerated alternative capable of producing meaningful metabolic adaptations

In conclusion, regular participation in supervised Pilates training not only improves anthropometric and fitness parameters but also reduces insulin resistance and circulating OSM levels. These results highlight the potential of Pilates as an effective non-pharmacological strategy for reducing cardiometabolic risk in inactive obese men. Future research with larger samples, longer follow-up periods, and direct assessments of adipose tissue mechanisms is warranted to further elucidate the underlying pathways.

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Conflicts of Interest:

There are no conflicts of interest.

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