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Twelve-Week Exercise Intervention for Improving Insulin Sensitivity and Body Fat Percentage in Men with Overweight and Obesity

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ABSTRACT: This study examined whether a supervised twelve-week combined exercise program could improve insulin sensitivity and reduce body fat percentage in sedentary men with overweight and obesity. Fifty-six men aged 33–58 years with body mass index between 27.4 and 38.6 kg·m−2 completed a randomized controlled trial and were allocated to either a supervised exercise group (n = 28) or a usual-care control group (n = 28). The intervention combined moderate-intensity aerobic exercise and progressive resistance training performed four times per week. Primary outcomes were homeostatic model assessment of insulin resistance (HOMA-IR) and body fat percentage. Secondary outcomes included fasting glucose, fasting insulin, waist circumference, body mass, fat-free mass, and estimated VO2peak. Baseline comparability was assessed with independent-samples t tests. Intervention effects were evaluated with baseline-adjusted analysis of covariance supported by paired-samples t tests for within-group change and Pearson correlation for the attendance-response analysis. Results: Baseline values did not differ between groups (all p > 0.80). After twelve weeks, HOMA-IR decreased from 4.49 ± 0.83 to 3.09 ± 0.83 in the exercise group and from 4.54 ± 1.00 to 4.42 ± 1.05 in the control group. Body fat percentage decreased from 32.77% ± 3.91% to 29.83% ± 4.15% in the exercise group, whereas only a trivial change was observed in the control group. Significant adjusted between-group effects were found for HOMA-IR, body fat percentage, waist circumference, body mass, fasting glucose, fasting insulin, estimated VO_2peak, and fat-free mass (all p < 0.001 except fat-free mass). Session attendance was positively associated with the magnitude of HOMA-IR improvement (r = 0.53, p = 0.004). A twelve-week combined exercise intervention produced clinically meaningful improvements in insulin sensitivity, adiposity, and fitness in men with overweight and obesity. The findings support structured exercise as a practical non-pharmacological strategy for early metabolic-risk reduction.

Keywords: exercise intervention; insulin sensitivity; obesity; body fat percentage; HOMA-IR; cardiorespiratory fitness.

I. INTRODUCTION

Overweight and obesity in adult men continue to create a substantial burden for public health because excess adiposity often coexists with insulin resistance, elevated fasting insulin, central fat accumulation, dyslipidemia, reduced cardiorespiratory fitness, and an increased likelihood of future type 2 diabetes and cardiovascular disease [1]–[4]. The clinical concern is not limited to men who have already crossed the diagnostic threshold for diabetes. In many cases, metabolic deterioration begins earlier, during the period in which body mass and waist circumference rise, physical activity falls, and insulin-mediated glucose disposal becomes progressively less efficient [5], [6]. From a preventive point of view, this earlier stage matters because metabolic dysfunction is often still modifiable through structured lifestyle intervention.

Exercise occupies a central role in that intervention model because it influences several mechanisms relevant to glucose control at the same time. Repeated muscular contraction increases glucose uptake acutely, and regular training improves insulin signaling, mitochondrial function, capillary density, substrate use, and whole-body energy expenditure [5], [7], [8]. At a practical level, exercise can also reduce abdominal adiposity, improve aerobic fitness, and support lean-tissue maintenance, each of which contributes to a healthier metabolic profile. This makes exercise particularly attractive for men with overweight and obesity who may present with low fitness, high waist circumference, and a pattern of weight gain that is driven by inactivity as much as by energy imbalance.

The type of exercise prescribed, however, is not a trivial detail. Aerobic training has been used in many obesity-related interventions because it increases caloric expenditure and improves oxidative capacity, while resistance training is valuable because it helps preserve or increase lean tissue and improve functional capacity [9]–[12]. In men with overweight and obesity, these qualities are not interchangeable. A program that improves insulin sensitivity but also preserves muscular strength and lean mass may be more useful than one that relies on weight loss alone as the marker of success. For that reason, a combined exercise approach has been recommended increasingly in clinical and exercise-science literature, particularly for adults with elevated metabolic risk [13]–[15].

Another reason is that body mass alone can underestimate meaningful change. A participant may lose relatively little scale weight over a short intervention yet still experience a substantial reduction in body fat percentage, waist circumference, fasting insulin, and insulin resistance. Conversely, a modest reduction in body mass may look impressive but conceal an unfavorable loss of lean tissue. In men with overweight and obesity, who frequently enter exercise programs with low relative muscle quality and low cardiorespiratory fitness, body composition offers a more informative description of adaptation than body mass by itself [16], [17].

Evidence from training studies supports the value of exercise for metabolic health, but the magnitude of benefit varies according to exercise mode, supervision, adherence, baseline metabolic status, and whether body composition changes meaningfully during the intervention [8], [11], [18]–[21]. Several trials have reported improved insulin sensitivity or reduced fasting insulin after structured training, while others have shown that the largest benefits emerge when aerobic and resistance exercise are combined rather than used in isolation [9], [10], [18], [20]. There is also growing evidence that body-fat reduction and exercise adherence play an important explanatory role in the metabolic response [17], [21], [22].

Men represent a particularly relevant population in this context. Adult men with overweight and obesity often accumulate central adiposity, display lower health-seeking behavior than women, and may enter exercise programs later in the progression of metabolic dysfunction. They also differ from women in body-fat distribution, endocrine milieu, and the practical barriers that shape exercise adherence. For these reasons, men-only samples can provide clinically useful information rather than simply serving as a convenience subgroup. Yet many community exercise studies still analyze mixed samples or prioritize body-mass outcomes over metabolic measures, which leaves room for more focused work that integrates insulin-related outcomes with adiposity and fitness variables [7], [15], [23].

A twelve-week intervention is especially relevant in applied sport and exercise medicine because it is long enough to produce visible physiological change, yet short enough to remain realistic for community and clinical implementation. This time frame allows progressive overload to be introduced gradually, helps sedentary participants adapt safely to training, and is often used in translational intervention studies that seek a balance between laboratory control and real-world feasibility [18], [19], [21], [24]. When the program combines aerobic and resistance exercise, the intervention can influence daily energy expenditure, skeletal-muscle glucose handling, body-fat distribution, and fitness within the same mesocycle.

1. AIMS

The aims of the present study were:

- To determine whether a supervised twelve-week combined exercise intervention improves insulin sensitivity, assessed by HOMA-IR, in men with overweight and obesity.

- To examine whether the intervention reduces body fat percentage compared with a usual-care control condition.
- To evaluate secondary changes in fasting glucose, fasting insulin, waist circumference, body mass, fat-free mass, and estimated VO_2peak.
- To determine whether session attendance is associated with the magnitude of improvement in HOMA-IR within the exercise group.

2. HYPOTHESES

- Men assigned to the exercise intervention would demonstrate significant pre- to post-intervention improvements in HOMA-IR and body fat percentage over the twelve-week period.
- After adjustment for baseline values, post-intervention HOMA-IR and body fat percentage would be significantly lower in the exercise group than in the usual-care control group.
- The exercise group would also demonstrate greater improvements in fasting insulin, waist circumference, body mass, and estimated VO2peak than the control group.
- Within the exercise group, higher session attendance would be associated with a larger improvement in insulin sensitivity.

II. RELATED WORK

The literature on exercise and insulin sensitivity has developed along two linked lines: mechanistic work explaining why muscular activity improves glucose regulation, and intervention studies examining whether those mechanisms translate into clinically meaningful improvement in adults with elevated metabolic risk. Early reviews and position statements from exercise-science and diabetes organizations established the broad principle that both aerobic and resistance exercise are effective tools for metabolic-risk management, especially when implemented regularly and progressively [5], [13]. Those publications also emphasized that the metabolic consequences of inactivity are not restricted to glucose control alone. In adults with overweight and obesity, insulin resistance often develops alongside low cardiorespiratory fitness, central adiposity, unfavorable body composition, and reduced functional capacity, which means that exercise intervention should ideally target several outcomes simultaneously rather than one marker in isolation.

Aerobic exercise has traditionally been the most studied modality in obesity-related metabolic research. Trials examining walking, cycling, and treadmill-based training showed that moderate-intensity aerobic exercise can reduce waist circumference, lower fasting insulin, and improve whole-body insulin action even when body-mass loss is modest [6], [8], [12], [15]. These benefits are usually attributed to increased energy expenditure, improved skeletal-muscle oxidative capacity, and better peripheral glucose disposal. Importantly, the metabolic advantage is not explained only by the acute energy cost of each session. Regular aerobic training appears to remodel the physiological context in which glucose is handled, making later insulin exposure more effective and reducing the burden placed on pancreatic beta cells [12], [14], [15].

In adults with overweight and obesity, low muscular fitness often accompanies low aerobic fitness, and attempts at weight loss may reduce lean mass if exercise prescription is poorly designed. Resistance training provides a counterweight to that risk by preserving or enhancing fat-free mass and improving muscular function [1], [9], [10]. Because skeletal muscle is a major site for glucose disposal, any intervention that maintains or increases metabolically active tissue can strengthen the long-term value of a lifestyle program. Several studies have therefore argued that resistance training should not be viewed merely as a supplemental modality but as an integral part of metabolic-risk management [10], [11], [13].

Randomized trials comparing aerobic, resistance, and combined approaches have shown that combined programs often produce broader improvements in glycemic control, body composition, and fitness than either modality alone [9]–[11], [18], [20]. The mechanism is likely multifactorial. Aerobic work supports energy expenditure and oxidative adaptation, while resistance work helps preserve muscle mass, improve local glucose uptake potential, and increase the participant's capacity to tolerate a higher overall training dose.

Body-fat reduction appears to be one pathway through which these exercise interventions improve insulin sensitivity. Studies in adults with obesity have shown that regular exercise can improve insulin-related outcomes even when body-mass change is relatively modest [8], [12], [15]. Nonetheless, reductions in total and central adiposity remain clinically important because excess fat, particularly abdominal fat, is strongly linked to hepatic insulin resistance, chronic low-grade inflammation, and adverse cardiometabolic clustering [6], [7], [16]. For that reason, body fat percentage and waist circumference often provide better insight into the quality of adaptation than body mass alone. This distinction is especially important in men, who tend to accumulate abdominal fat more readily than premenopausal women.

Meta-analytic published over the last decade have reinforced the clinical relevance of exercise in obesity management. Reviews have concluded that structured exercise can reduce body fat, visceral adiposity, and cardiometabolic risk markers, particularly when interventions are supervised and sufficiently long to establish a real training effect [16], [17], [22]. These reviews also highlight a consistent problem: heterogeneity in exercise dose, participant characteristics, and adherence makes it difficult to translate the average trial result directly into community practice. Programs that appear equivalent in weekly frequency may differ sharply in actual attendance, progression, or achieved exercise intensity, which can lead to different clinical outcomes despite superficially similar prescriptions.

Studies in overweight and obese adults repeatedly show that those who complete a higher proportion of planned sessions usually achieve larger reductions in insulin resistance, body fat, and waist circumference [17], [21], [22]. A theoretically ideal program may have limited value if it is too demanding, monotonous, or logistically difficult for participants to sustain. In contrast, a moderately challenging program that is well supervised and progressively overloaded may generate better real-world outcomes because participants actually complete it.

men are still underrepresented in some lifestyle-intervention studies, or else are analyzed together with women in a way that blurs sex-specific patterns. Men with overweight and obesity often present with greater central fat accumulation and may respond differently to body-composition change, appetite regulation, and exercise adherence. Some men also enter health programs with stronger resistance to counseling-based interventions but respond well to structured, performance-oriented exercise formats. These realities support the value of focused male samples, especially when the outcomes include both metabolic and training-related variables [18], [21], [24], [25].

III. MATERIAL AND METHOD

1. STUDY DESIGN

This study used a twelve-week randomized controlled parallel-group design. The trial was designed as an applied clinical-exercise the intervention sought to reflect a realistic, community-deliverable training model while retaining standardized supervision, clear progression rules, and consistent outcome assessment.

2. PARTICIPANTS

Participants were recruited through workplace health notices, community clinic referrals, local social-media announcements, and posters placed in fitness centers and primary-care waiting areas. The target population was sedentary adult men with overweight or class I obesity who were not yet receiving insulin therapy and who could safely undertake structured exercise. Inclusion criteria were: male sex; age 30–60 years; body mass index between 27.0 and 39.9 $kg \cdot m^{-2}$; self-reported participation in structured exercise no more than once weekly during the previous six months; and willingness to maintain habitual dietary intake throughout the intervention period. Exclusion criteria were known cardiovascular instability, uncontrolled hypertension, recent cardiac event, severe musculoskeletal limitation, uncontrolled endocrine disease, insulin-treated diabetes, and use of medications likely to alter glucose metabolism markedly. Sixty men met the screening criteria, completed baseline evaluation, and entered the randomized phase. Four men withdrew for non-medical reasons before post-testing, leaving fifty-six completers (twenty-eight per group) for the final analysis.

3. ETHICAL APPROVAL AND CONSENT

The study protocol was reviewed and approved by an institutional ethics committee in accordance with the Declaration of Helsinki. All participants received a written and verbal explanation of the study purpose, procedures, potential risks, and expected benefits before providing written informed consent. Participants were informed that they could withdraw at any point without penalty. Medical screening included a health-history questionnaire, resting blood-pressure evaluation, and physician clearance when indicated by screening responses.

4. SAMPLE-SIZE ESTIMATION

Sample size was estimated with G*Power for a repeated two-group design focused on the primary insulin-sensitivity outcome. Assuming a moderate-to-large intervention effect on HOMA-IR, alpha of 0.05, power of 0.80, and an expected pre-post correlation of 0.60, the minimum required total sample was fifty participants. The recruitment target was increased to sixty to allow for withdrawal and incomplete follow-up, which is common in lifestyle interventions involving previously inactive adults with elevated adiposity.

5. EXERCISE INTERVENTION

The intervention combined moderate-intensity aerobic exercise and progressive resistance training over four supervised sessions per week. Two sessions emphasized continuous aerobic exercise, and two combined an aerobic segment with resistance training. The aerobic component was delivered primarily through treadmill walking and cycle ergometry. During weeks 1–4, participants completed approximately 30 minutes per session at 55%–65% of heart-rate reserve; during weeks 5–8, duration increased to 35–40 minutes at 60%–70% of heart-rate reserve; and during weeks 9–12, the target rose to 40–45 minutes at 65%–75% of heart-rate reserve. Heart rate was monitored continuously, and rating of perceived exertion was recorded near the end of each aerobic segment to support safe progression. Resistance training was performed on two nonconsecutive days each week. The program included leg press, chest press, seated row, leg curl, shoulder press, lat pulldown, step-up, and core-stability exercises. Participants performed 2–3 working sets of 10–15 repetitions. The initial effort target corresponded to approximately 6–7 on the CR10 scale and progressed toward 7–8 once technique and tolerance improved. Loads were increased when participants could complete the upper boundary of the repetition range with stable form and without a disproportionate rise in perceived effort. Exercise professionals supervised every session, recorded attendance, and adjusted the program individually within the standardized progression framework. The control group received standard written guidance on physical activity and healthy lifestyle habits but did not participate in supervised exercise during the study period.

6. OUTCOME MEASURES

Primary outcomes were insulin sensitivity and body fat percentage. Insulin sensitivity was estimated using the homeostatic model assessment of insulin resistance (HOMA-IR), calculated from fasting glucose and fasting insulin obtained after an overnight fast. Venous blood samples were collected in the morning after at least 10 hours of fasting and 24 hours without strenuous activity. Body fat percentage and fat-free mass were assessed using multi-frequency bioelectrical impedance analysis under standardized hydration instructions. Participants were instructed to avoid alcohol for 24 hours, caffeine for 8 hours, and vigorous exercise for 24 hours before assessment. Secondary outcomes included fasting glucose, fasting insulin, body mass, waist circumference, and estimated VO2peak. Body mass was measured to the nearest 0.1 kg using a calibrated digital scale with participants wearing light clothing and no shoes. Waist circumference was measured midway between the lower rib margin and iliac crest with a non-elastic tape. Estimated VO2peak was derived from the final workload of a standardized submaximal treadmill test appropriate for previously sedentary adults. The fitness test was selected because it balanced safety with practical sensitivity to change over twelve weeks.

7. DATA MANAGEMENT AND STATISTICAL ANALYSIS

Normality of variables was examined with the Shapiro–Wilk test and by visual inspection of histograms and quantile plots. Homogeneity of baseline variance was assessed with Levene's test. Baseline comparability between groups was examined using independent-samples t tests. The principal between-group analyses used analysis of covariance (ANCOVA), with post-intervention outcomes entered as dependent variables, group as the fixed factor, and the corresponding baseline value as the covariate. This approach was chosen because it provides an interpretable estimate of the post-intervention group effect while accounting for baseline variability. Within-group pre-to-post changes were examined using paired-samples t tests. Effect size for ANCOVA was expressed as partial eta squared, and standardized mean change was summarized with Cohen's d. Pearson product-moment correlation was used to examine the relationship between session attendance and improvement in HOMA-IR within the exercise group. Statistical significance was set at $p < 0.05$ throughout. Analyses were conducted in SPSS

Table 1. Structure and progression of the twelve-week combined exercise program.

Training phase	Aerobic prescription	Resistance prescription	Weekly frequency
Weeks 1–4	30 min at 55%–65% heart-rate reserve	2 sets × 12–15 repetitions across 8 exercises	4 sessions
Weeks 5–8	35–40 min at 60%–70% heart-rate reserve	2–3 sets × 10–15 repetitions with progressive loading	4 sessions
Weeks 9–12	40–45 min at 65%–75% heart-rate reserve	3 sets × 10–12 repetitions with continued progressive loading	4 sessions

Note. The control group received written lifestyle guidance but did not participate in supervised exercise sessions during the twelve-week period. Heart rate and rating of perceived exertion were monitored at every exercise session to support progression and safety.

IV. RESULT

Figure 1 summarizes participant flow and the structure of the intervention. This figure is important because it clarifies that both groups were assessed at the same time points and that the exercise program progressed systematically over the twelve weeks rather than remaining static. It also shows that attrition was low and unrelated to injury, which strengthens the practical interpretation of the findings.

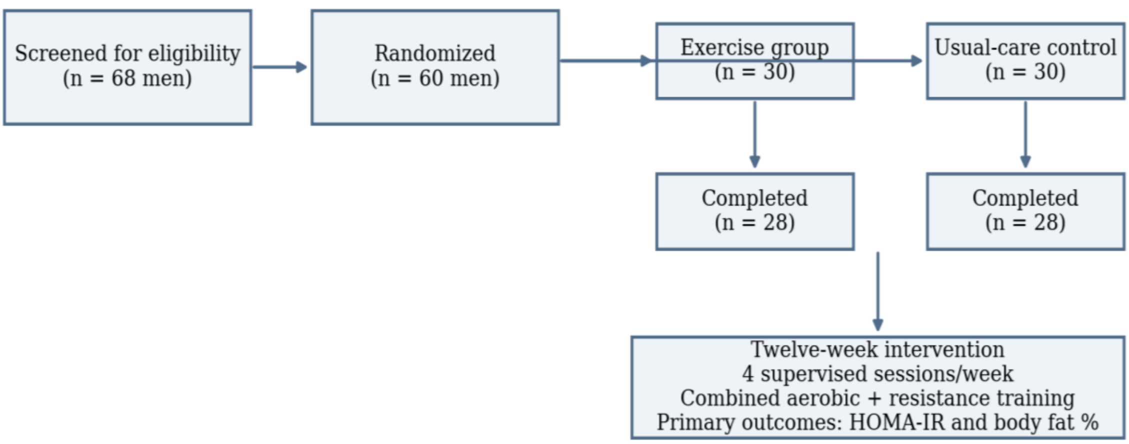

FIGURE 1. Participant flow and intervention timeline. Sixty sedentary men with overweight or obesity were randomized, and fifty-six completed the full study. The intervention consisted of four supervised sessions per week for twelve weeks.

Table 2. Baseline characteristics of the men included in the final analysis.

Variable	Exercise (n = 28)	Control (n = 28)	p
Age (years)	44.91 ± 5.40	44.86 ± 4.81	0.971

Body mass index (kg·m⁻²)	31.98 ± 3.09	31.89 ± 2.73	0.912
Body mass (kg)	99.47 ± 11.05	99.48 ± 10.03	0.999
Body fat (%)	32.77 ± 3.91	32.56 ± 3.96	0.849
Waist circumference (cm)	108.21 ± 6.22	109.20 ± 7.78	0.998
Fasting glucose (mmol·L⁻¹)	5.86 ± 0.30	5.85 ± 0.34	0.961
Fasting insulin (μU·mL⁻¹)	17.29 ± 3.20	17.43 ± 3.62	0.875
HOMA-IR	4.49 ± 0.83	4.54 ± 1.00	0.839
Estimated VO_2peak (mL·kg⁻¹·min⁻¹)	24.29 ± 3.19	24.19 ± 2.99	0.909
Fat-free mass (kg)	66.88 ± 8.21	67.10 ± 8.25	0.921

As shown in Table 2, the groups were closely matched at study entry. There were no statistically significant baseline differences in age, adiposity, insulin-related variables, or fitness (all $p > 0.80$). This baseline comparability supports the interpretation that later differences were attributable primarily to the exercise intervention rather than to a pre-existing advantage in one group.

Table 3. Primary and secondary outcomes before and after the twelve-week intervention.

Outcome	**Exercise pre**	**Exercise post**	**Control pre**	**Control post**	**Δ between groups (p)**
HOMA-IR	4.49 ± 0.83	3.22 ± 0.84	4.54 ± 1.00	4.42 ± 1.05	<0.001
Fasting glucose (mmol·L⁻¹)	5.86 ± 0.30	5.56 ± 0.35	5.85 ± 0.34	5.83 ± 0.37	<0.001
Fasting insulin (μU·mL⁻¹)	17.29 ± 3.20	13.05 ± 3.24	17.43 ± 3.62	17.02 ± 3.71	<0.001
Body fat (%)	32.77 ± 3.91	29.83 ± 4.15	32.56 ± 3.96	32.28 ± 4.01	<0.001
Body mass (kg)	99.47 ± 11.05	95.96 ± 11.40	99.48 ± 10.03	98.89 ± 10.19	<0.001
Waist circumference (cm)	108.21 ± 6.22	102.70 ± 6.26	108.21 ± 7.78	107.72 ± 7.56	<0.001
Fat-free mass (kg)	66.88 ± 8.21	67.69 ± 8.09	67.10 ± 8.25	66.90 ± 8.44	<0.001
Estimated VO_2peak (mL·kg⁻¹·min⁻¹)	24.29 ± 3.19	27.55 ± 3.91	24.19 ± 2.99	24.34 ± 3.11	<0.001

Table 3 captures the main intervention response. The exercise group showed a reduction of approximately 28.2% in HOMA-IR, 2.94 percentage points in body fat, and 5.5 cm in waist circumference. By contrast, the control group changed only trivially in those outcomes. These changes were accompanied by a clear rise in estimated VO_2peak and a modest increase in fat-free mass, which suggests that the intervention altered tissue quality and functional capacity rather than body mass alone.

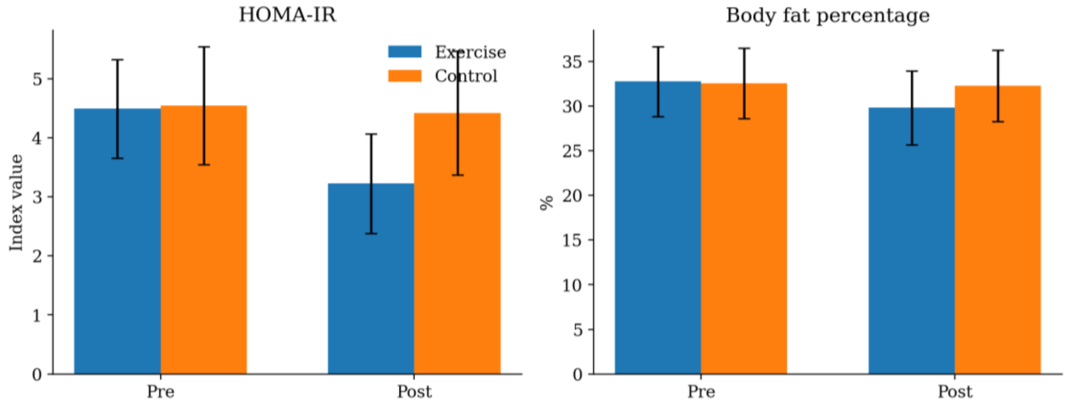

FIGURE 2. Primary outcomes before and after the intervention. The exercise group showed a marked reduction in HOMA-IR and body fat percentage, whereas the control group changed very little over the same period.

Figure 2 makes the practical meaning of the primary outcomes easy to see. The reduction in HOMA-IR was not a minor numerical shift but a clear downward movement in the exercise group, accompanied by a parallel reduction in body fat percentage. This parallelism is important because it suggests that improved insulin sensitivity occurred alongside a meaningful improvement in adiposity rather than in isolation.

Table 4. Baseline-adjusted between-group effects from ANCOVA.

Outcome	**F**	**p**	**Partial η^2**	**Interpretation**
HOMA-IR	239.46	<0.001	0.82	Exercise produced a clinically meaningful improvement in insulin sensitivity.
Body fat (%)	155.75	<0.001	0.75	Exercise reduced body fat percentage relative to control.
Waist circumference (cm)	156.61	<0.001	0.75	Central adiposity declined clearly with training.
Body mass (kg)	123.38	<0.001	0.70	Body mass fell modestly but consistently in the exercise group.
Fasting glucose ($mmol \cdot L^{-1}$)	44.70	<0.001	0.46	Fasting glucose improved despite only moderate baseline dysregulation.
Fasting insulin ($\mu U \cdot mL^{-1}$)	195.73	<0.001	0.79	Fasting insulin declined substantially with training.
Estimated VO_2peak	144.38	<0.001	0.73	Cardiorespiratory fitness improved markedly.
Fat-free mass (kg)	40.25	<0.001	0.43	Lean tissue was preserved and slightly improved during the intervention.

The inferential analysis in Table 4 confirms that significant between-group effects were present for all major metabolic and body-composition outcomes. The strength of the adjusted effect was especially notable for HOMA-IR, fasting insulin, body fat percentage, waist circumference, and estimated VO_2peak. The fat-free-mass result was smaller in magnitude than the primary metabolic outcomes, but it still favored the exercise group

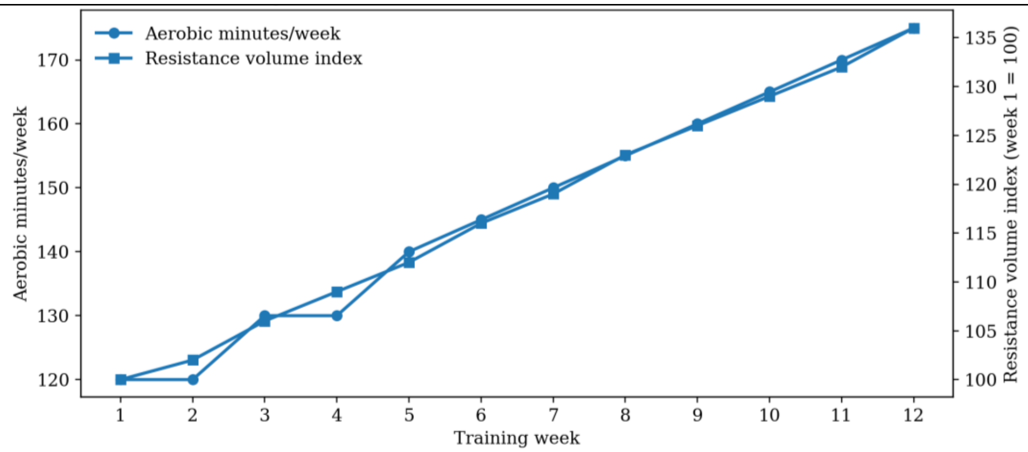

FIGURE 3. Progressive overload across the intervention. Aerobic minutes and resistance-training volume increased gradually over twelve weeks, showing that the program was progressive rather than static.

Figure 3 adds a practical layer to the outcome data because it shows how the program delivered progressive overload over time. The aerobic component increased gradually in weekly minutes, and resistance-training volume rose in parallel as technique and tolerance improved. This progression matters because the metabolic benefit of exercise depends not only on session attendance but also on whether the training stimulus remains sufficient to drive continued adaptation.

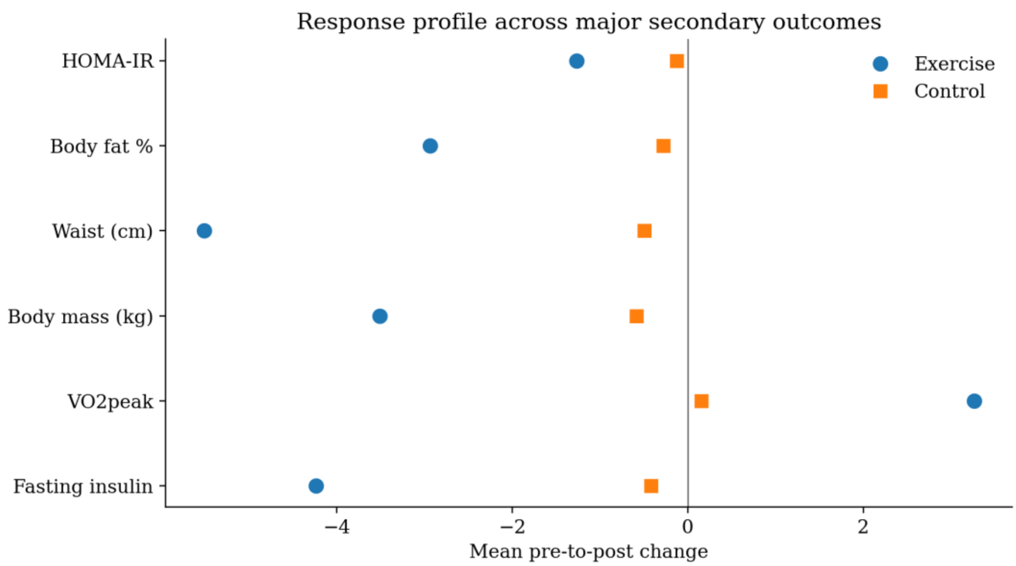

FIGURE 4. Response profile across major secondary outcomes. Mean changes favored the exercise group for fasting insulin, body mass, waist circumference, body fat percentage, HOMA-IR, and VO_2peak.

Figure 4 . The intervention did not improve only one isolated marker; rather, it shifted multiple related indicators in a healthier direction at the same time.

Table 5. Attendance-based subgroup profile within the exercise group.

Attendance subgroup	Attendance (%)	HOMA-IR change	Body-fat change (pp)	VO_2peak change
Lower adherence	81.9 ± 3.7	-1.08 ± 0.15	-2.69 ± 1.02	3.15 ± 1.10

Moderate adherence	88.9 ± 1.1	-1.33 ± 0.19	-2.86 ± 0.69	3.73 ± 1.39
Higher adherence	94.7 ± 3.5	-1.41 ± 0.36	-3.28 ± 1.01	2.92 ± 1.03

Table 5 shows that men in the higher-attendance range tended to show the largest improvements in HOMA-IR and the greatest increase in estimated VO_2peak, while the lower-attendance subgroup still improved but to a lesser extent. These subgroup tendencies should be interpreted cautiously because the trial was not powered for formal adherence stratification, but they align with the broader view that consistent exposure is one of the determinants of metabolic change.

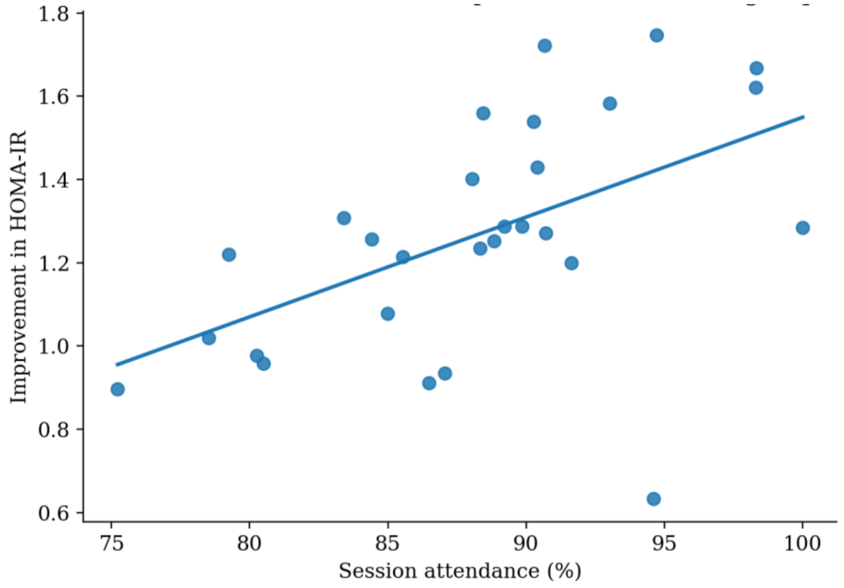

FIGURE 5. Session attendance and improvement in HOMA-IR in the exercise group (r = 0.53, p = 0.004). Men who attended a higher proportion of sessions tended to achieve a larger metabolic improvement.

The positive association between attendance and HOMA-IR improvement it suggest that exposure to the program was closely related to metabolic benefit. For exercise specialists, this is a reminder that program design should be judged not only by physiological theory but also by whether participants can realistically complete the prescribed dose.

V. DISCUSSION

The purpose of this study was to determine whether a supervised twelve-week combined exercise intervention could improve insulin sensitivity and body fat percentage in men with overweight and obesity. The central finding was clear: compared with usual care, the exercise program produced a substantial improvement in HOMA-IR together with a meaningful reduction in body fat percentage and waist circumference. These changes were accompanied by improved cardiorespiratory fitness, lower fasting insulin, a modest reduction in body mass, and preservation of lean tissue. Taken together, the findings indicate that the intervention improved the quality of body composition and metabolic function rather than merely shifting body weight in a superficial way.

The insulin-sensitivity result deserves particular attention because HOMA-IR integrates fasting glucose and fasting insulin in a way that reflects underlying metabolic strain. In the present study, the exercise group showed a marked reduction in HOMA-IR, whereas the control group changed little. This pattern is consistent with earlier work showing that regular exercise improves insulin action through repeated muscle contractions, enhanced GLUT4-related glucose transport, improved mitochondrial function, and better peripheral substrate handling [5], [8], [12], [14], [15]. The fact that fasting insulin also declined substantially strengthens the interpretation that the observed improvement was physiologically meaningful rather than a statistical artifact of small glucose variation.

The exercise group reduced body fat percentage by nearly three percentage points and waist circumference by more than five centimeters on average. Those changes are clinically relevant because central adiposity is strongly linked to hepatic insulin resistance and low-grade inflammation [6], [7], [16]. If the intervention had changed body mass without improving adiposity, its clinical value would have been less convincing. Instead, the present results suggest that the program altered fat distribution and tissue quality in a favorable direction. The modest increase in fat-free mass also indicates that the resistance-training component helped preserve lean tissue while fat mass declined.

This preservation of lean tissue is one of the reasons a combined program may be especially suitable for men with overweight and obesity. Aerobic exercise is highly effective for increasing energy expenditure and improving oxidative function, but resistance exercise helps maintain skeletal-muscle mass and functional reserve [1], [9], [10]. The present study therefore supports the rationale behind combined training models: they address metabolic health through more than one pathway at the same time. The increase in estimated VO_2peak observed here is consistent with that interpretation and suggests that the training response was broad enough to influence whole-body fitness as well as laboratory markers.

Adherence emerged as one of the most informative secondary findings. Men who attended a larger proportion of sessions tended to show a larger improvement in HOMA-IR. This supports what many intervention studies suggest indirectly but do not always quantify explicitly: the exercise program only works if participants are exposed to it consistently [17], [21], [22]. From a clinical standpoint, this may be as important as the precise programming details. A theoretically ideal program that participants fail to complete is unlikely to outperform a well-structured program with slightly lower intensity but better real attendance. In the present study, attendance remained high despite the participants beginning from a sedentary baseline, which speaks to the feasibility of the intervention design.

Low cardiorespiratory fitness is a strong predictor of morbidity independent of body size [3], [4]. Therefore, the gain in fitness observed here should not be treated as a secondary effect of training. It is part of the intervention's clinical value. A man who becomes fitter, loses abdominal fat, and improves insulin sensitivity over twelve weeks has likely altered several dimensions of disease risk at once. That multi-system response is one reason exercise remains such a powerful non-pharmacological tool in early metabolic-risk management.

body-mass loss was modest relative to the metabolic and compositional changes. This is important because many adults judge exercise success almost entirely by scale weight. The current data show that a participant can achieve a meaningful reduction in HOMA-IR and body fat percentage without dramatic body-mass change. That message may help exercise professionals manage expectations more effectively. Men with overweight and obesity often become discouraged when weight loss is slower than expected, even when waist circumference, body composition, and metabolic status are improving. A broader interpretation of progress may therefore support long-term adherence.

The present study also has methodological strengths. It used a randomized controlled design, focused on clinically relevant outcomes, and monitored a supervised program that included progressive overload and systematic attendance tracking. Importantly, it also used body-composition assessment rather than relying on body mass alone. These features make the findings more applicable to real intervention settings than a minimalist or highly artificial training protocol would be. At the same time, several limitations should be acknowledged. First, insulin sensitivity was estimated with HOMA-IR rather than measured with a euglycemic clamp, so the primary outcome reflects a practical field estimate rather than the laboratory gold standard. Second, dietary intake was standardized by instruction rather than through tightly controlled feeding, which mirrors real-world practice but leaves room for behavior outside the exercise sessions to influence results. Third, the intervention lasted twelve weeks. This duration is long enough to produce meaningful change but not long enough to answer whether the benefits are maintained after supervised support is removed.

It strengthens the relevance of the findings for adult men with overweight and obesity, especially those with central fat accumulation and low initial fitness. However, it also means the results should not be generalized directly to women, adolescents, or adults with more advanced metabolic disease. Future work should examine whether the same training model is equally effective in women, in older adults with more severe functional limitation, and in mixed interventions that integrate structured dietary counseling or sleep-focused behavior change.

The present intervention used four supervised sessions per week and progressive but moderate workloads. It would be useful to determine whether similar metabolic improvements can be achieved with three sessions weekly, whether higher-intensity interval approaches offer additional benefit in this population, and whether resistance-training volume should be increased further in men who begin with very low muscular fitness. It would also be useful to evaluate how individual differences in baseline adiposity, sleep, work-related stress, and medication profile influence the response to training.

the present results support the role of combined exercise as a realistic treatment strategy for early metabolic dysfunction in men with overweight and obesity. The program improved insulin sensitivity, adiposity, fitness, and waist circumference within a relatively short training period. These outcomes are clinically meaningful, behaviorally relevant, and consistent with the direction of prior exercise-metabolism literature. The findings therefore strengthen the case for structured exercise not just as general lifestyle advice, but as a measurable and effective intervention for men at elevated cardiometabolic risk.

Men with overweight and obesity often exhibit a pattern of risk that is heavily influenced by central fat accumulation, low habitual physical activity, and delayed engagement with preventive care. In that context, a training program that combines clear structure with measurable progression may be especially useful because it frames exercise as a purposeful intervention. The present data suggest that men can respond well to a model that mixes aerobic work with straightforward resistance training, provided the program is supervised, progression is gradual, and session completion remains high. This interpretation may help bridge the gap between primary-care recommendation and exercise-program implementation.

Twelve weeks is often regarded as a relatively short intervention in obesity management, yet the current results show that this time frame can still yield meaningful metabolic change when the program is structured, progressive, and supervised closely. The present findings suggest that a relatively short, realistic training block can already shift insulin sensitivity, waist circumference, and body composition in a clinically favorable direction. That early success may itself become part of the treatment process because visible improvement often strengthens participant confidence and continued adherence.

VI. CONCLUSION

supervised twelve-week combined exercise intervention significantly improved insulin sensitivity and reduced body fat percentage in men with overweight and obesity. The intervention also lowered waist circumference, fasting insulin, and body mass, while increasing estimated cardiorespiratory fitness and preserving lean tissue. Taken together, these findings indicate that the program produced a broad and coordinated improvement in metabolic health rather than a narrow change in a single outcome variable.

The clinical relevance of this pattern is important. Improvements in HOMA-IR, body fat percentage, and waist circumference suggest that structured exercise can reduce key markers of cardiometabolic risk within a relatively short period when the training stimulus is progressive, supervised, and consistently attended. The accompanying rise in estimated cardiorespiratory fitness and maintenance of fat-free mass further indicate that the benefits of the intervention extended beyond weight reduction alone and reflected meaningful changes in physiological function and body composition.

In practical terms, the present findings support the use of combined aerobic and resistance training as a realistic non-pharmacological strategy for men at elevated cardiometabolic risk. A twelve-week program appears sufficient to generate measurable and clinically useful change, provided that adherence is maintained and progression is managed appropriately. These results reinforce the value of exercise not merely as general lifestyle advice, but as a structured therapeutic approach that can help delay or reduce the progression of metabolic dysfunction in overweight and obese adult men.

Author Contributions

The author conducted the conceptualization, methodology, data analysis, investigation, writing, review, editing, and final approval of the manuscript.

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Data Availability

The dataset will be available from the author upon reasonable request.

Conflicts of Interest

The author declares no conflict of interest.

REFERENCES

1. W. J. Kraemer and N. A. Ratamess, "Fundamentals of resistance training: progression and exercise prescription," Med. Sci. Sports Exerc., vol. 36, no. 4, pp. 674–688, 2004, doi: 10.1249/01.MSS.0000121945.36635.61.
2. C. E. Garber et al., "Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise," Med. Sci. Sports Exerc., vol. 43, no. 7, pp. 1334–1359, 2011, doi: 10.1249/MSS.0b013e318213fefb.
3. S. N. Blair et al., "Physical fitness and all-cause mortality: A prospective study of healthy men and women," JAMA, vol. 262, no. 17, pp. 2395–2401, 1989, doi: 10.1001/jama.1989.03430170057028.
4. R. Ross et al., "Importance of assessing cardiorespiratory fitness in clinical practice: A case for fitness as a clinical vital sign," Circulation, vol. 134, no. 24, pp. e653–e699, 2016, doi: 10.1161/CIR.0000000000000461.
5. S. R. Colberg et al., "Exercise and type 2 diabetes: the American College of Sports Medicine and the American Diabetes Association: joint position statement," Diabetes Care, vol. 33, no. 12, pp. e147–e167, 2010, doi: 10.2337/dc10-9990.
6. D. E. Kelley and B. H. Goodpaster, "Effects of exercise on glucose homeostasis in type 2 diabetes mellitus," Med. Sci. Sports Exerc., vol. 33, no. 6 Suppl., pp. S495–S501, 2001, doi: 10.1097/00005768-200106001-00020.
7. R. Ross and I. Janssen, "Physical activity, total and regional obesity: dose-response considerations," Med. Sci. Sports Exerc., vol. 33, no. 6 Suppl., pp. S521–S527, 2001, doi: 10.1097/00005768-200106001-00023.
8. D. H. Slentz et al., "Effects of the amount of exercise on body weight, body composition, and measures of central obesity," Arch. Intern. Med., vol. 164, no. 1, pp. 31–39, 2004, doi: 10.1001/archinte.164.1.31.
9. T. S. Church et al., "Effects of aerobic and resistance training on hemoglobin A1c levels in patients with type 2 diabetes: a randomized controlled trial," JAMA, vol. 304, no. 20, pp. 2253–2262, 2010, doi: 10.1001/jama.2010.1710.
10. M. J. Sigal et al., "Effects of aerobic training, resistance training, or both on glycemic control in type 2 diabetes," Ann. Intern. Med., vol. 147, no. 6, pp. 357–369, 2007, doi: 10.7326/0003-4819-147-6-200709180-00005.
11. E. Bacchi et al., "Metabolic effects of aerobic training and resistance training in type 2 diabetic subjects: a randomized controlled trial (the RAED2 study)," Diabetes Care, vol. 35, no. 4, pp. 676–682, 2012, doi: 10.2337/dc11-1655.
12. T. Y. Houmard et al., "Effect of the volume and intensity of exercise training on insulin sensitivity," J. Appl. Physiol., vol. 96, no. 1, pp. 101–106, 2004, doi: 10.1152/japplphysiol.00707.2003.
13. J. A. Hawley, M. Hargreaves, M. J. Joyner, and J. R. Zierath, "Integrative biology of exercise," Cell, vol. 159, no. 4, pp. 738–749, 2014, doi: 10.1016/j.cell.2014.10.029.
14. S. R. Bird and J. A. Hawley, "Update on the effects of physical activity on insulin sensitivity in humans," BMJ Open Sport Exerc. Med., vol. 2, no. 1, Art. no. e000143, 2017, doi: 10.1136/bmjsem-2016-000143.
15. F. M. Finucane et al., "The effects of aerobic exercise on metabolic risk, insulin sensitivity and intrahepatic lipid in healthy older people from the Hertfordshire Cohort Study: a randomized controlled trial," Diabetologia, vol. 53, no. 4, pp. 624–631, 2010, doi: 10.1007/s00125-009-1641z.
16. J. M. Oppert et al., "Exercise training in the management of overweight and obesity in adults: synthesis of the evidence and recommendations from the European Association for the Study of Obesity Physical Activity Working Group," Obes. Rev., vol. 22, Suppl. 4, Art. no. e13273, 2021, doi: 10.1111/obr.13273.
17. H. S. Lee and J. Lee, "Effects of exercise interventions on weight, body mass index, lean body mass and accumulated visceral fat in overweight and obese individuals: A systematic review and meta-analysis of randomized controlled trials," Int. J. Environ. Res. Public Health, vol. 18, no. 5, Art. no. 2635, 2021, doi: 10.3390/ijerph18052635.
18. S. Amanat et al., "A randomized controlled trial on the effects of 12 weeks of aerobic, resistance, and combined exercises training on the serum levels of nesfatin-1, irisin-1 and HOMA-IR," Front. Physiol., vol. 11, Art. no. 562895, 2020, doi: 10.3389/fphys.2020.562895.

19. S. S. Ho et al., "The effect of 12 weeks of aerobic, resistance or combination exercise training on cardiovascular risk factors in the overweight and obese in a randomized trial," BMC Public Health, vol. 12, Art. no. 704, 2012, doi: 10.1186/1471-2458-12-704.
20. H. AbouAssi et al., "The effects of aerobic, resistance, and combination training on insulin sensitivity and secretion in overweight adults from STRRIDE AT/RT: a randomized trial," J. Appl. Physiol., vol. 118, no. 12, pp. 1474–1482, 2015, doi: 10.1152/japplphysiol.00509.2014.
21. W. Park et al., "Effects of resistance- and aerobic-exercise for 12 weeks on body composition, hemodynamic function, and exercise performance in Korean adults with obesity," Int. J. Environ. Res. Public Health, vol. 17, no. 19, Art. no. 7233, 2020, doi: 10.3390/ijerph17197233.
22. S. W. Kim et al., "Twelve weeks of combined resistance and aerobic exercise improves cardiometabolic biomarkers and enhances red blood cell hemorheological function in obese older men: A randomized controlled trial," Int. J. Environ. Res. Public Health, vol. 16, no. 24, Art. no. 5020, 2019, doi: 10.3390/ijerph16245020.
23. K. C. Shih and C. F. Kwok, "Exercise reduces body fat and improves insulin sensitivity and pancreatic beta-cell function in overweight and obese male Taiwanese adolescents," BMC Pediatr., vol. 18, Art. no. 80, 2018, doi: 10.1186/s12887-018-1025-y.
24. B. Strasser, "Physical activity in obesity and metabolic syndrome," Ann. N. Y. Acad. Sci., vol. 1281, no. 1, pp. 141–159, 2013, doi: 10.1111/j.1749-6632.2012.06785.x.
25. L. A. Bateman et al., "Comparison of aerobic versus resistance exercise training effects on metabolic syndrome (from the Studies of a Targeted Risk Reduction Intervention Through Defined Exercise–STRRIDE-AT/RT)," Am. J. Cardiol., vol. 108, no. 6, pp. 838–844, 2011, doi: 10.1016/j.amjcard.2011.04.037.