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Study of Impact of Weight Reduction on Clinical and Biochemical Parameters in Patients with Metabolic Syndrome at a Tertiary Care Centre

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ABSTRACT

Background: Metabolic syndrome is a cluster of interrelated cardiometabolic abnormalities associated with an increased risk of type 2 diabetes mellitus and cardiovascular disease. Weight reduction through structured lifestyle modification may improve its individual clinical and biochemical components. This study aimed to evaluate the impact of weight reduction on clinical and biochemical parameters among patients with metabolic syndrome.
Materials and Methods: A prospective, single-arm, non-randomized interventional study was conducted in the Department of Medicine, Government Medical College and Hospital, Chhatrapati Sambhajinagar, Maharashtra, India, from January to December 2025. A total of 175 adults with metabolic syndrome underwent a structured 12-week lifestyle intervention comprising dietary calorie restriction, dietary modification, and regular physical activity. Anthropometric measurements, blood pressure, fasting plasma glucose, glycated haemoglobin (HbA1c), and lipid profile were assessed at baseline and after 12 weeks. Participants were categorized according to achievement of ≥5% or <5% reduction in baseline body weight. Statistical significance was set at $p<0.05$.
Results: Following the 12-week intervention, significant reductions were observed in mean body weight (84.6±11.9 to 79.8±11.5 kg), body mass index (31.2±3.7 to 29.4±3.5 kg/m²), and waist circumference (103.8±9.1 cm, with a mean reduction of 5.7 cm) ($p<0.001$). Systolic and diastolic blood pressure decreased by 7.9 and 4.4 mmHg, respectively. Significant improvements were also observed in fasting plasma glucose (112.8±17.6 to 103.6±15.4 mg/dL), HbA1c (6.18±0.62% to 5.91±0.57%), triglycerides, LDL-C, total cholesterol, and HDL-C (all $p<0.001$). Overall, 93 (53.14%) participants achieved ≥5% weight reduction. Metabolic syndrome resolved in 60 (34.29%) participants, with a higher resolution rate among those achieving ≥5% weight loss than among those achieving <5% weight loss (45.16% vs. 21.95%; $p=0.001$).

Conclusion: A structured 12-week lifestyle intervention was associated with significant improvements in anthropometric, haemodynamic, glycaemic, and lipid parameters in patients with metabolic syndrome. Achievement of ≥5% weight reduction was associated with greater cardiometabolic improvement and a higher likelihood of metabolic syndrome resolution.

Keywords: Metabolic Syndrome; Weight Reduction; Obesity; Waist Circumference; Dyslipidaemia; Insulin Resistance; Lifestyle Modification

INTRODUCTION

Metabolic syndrome is characterized by the coexistence of several interrelated cardiometabolic abnormalities, including central adiposity, elevated blood pressure, impaired glucose regulation, hypertriglyceridaemia, and reduced high-density lipoprotein cholesterol (HDL-C). [1] Central obesity and insulin resistance are closely related to the development of this risk-factor cluster and contribute to an increased likelihood of type 2 diabetes and cardiovascular disease. The relevance of adiposity is particularly important among Asian Indians, who may develop metabolic abnormalities at comparatively lower body mass indices and have a propensity toward abdominal and visceral fat accumulation. [2]

Indian consensus recommendations therefore emphasize lower thresholds for overweight, obesity, and abdominal obesity and advocate early lifestyle intervention in individuals at increased cardiometabolic risk. [2,3] Weight reduction is a principal non-pharmacological strategy for managing metabolic syndrome because relatively modest reductions in body weight can influence several components simultaneously. Lifestyle interventions combining calorie reduction, healthier dietary composition, and regular physical activity have demonstrated improvements in waist circumference, blood pressure, glucose metabolism, triglycerides, HDL-C, and the overall prevalence or severity of metabolic syndrome. [4-9]

Randomized studies have subsequently shown that the metabolic response to lifestyle intervention varies according to the magnitude and sustainability of weight loss, the type of dietary intervention, exercise adherence, baseline metabolic status, and population characteristics. [5-9] Indian trials have also demonstrated meaningful improvement in cardiometabolic risk factors after structured diet- and activity-based lifestyle interventions. [6,7]

Evaluating changes in anthropometric parameters together with blood pressure, glycaemia, and lipid profile may help quantify the short-term metabolic benefit associated with weight reduction. The present study aimed to evaluate the impact of weight reduction on clinical and biochemical parameters among adults with metabolic syndrome and to compare outcomes according to achievement of clinically meaningful weight loss.

MATERIALS AND METHODS

This prospective single-arm, non-randomized before-and-after/interventional study was conducted in the Department of Medicine, Government Medical College and Hospital, Chhatrapati Sambhajinagar, Maharashtra, India, between January and December 2025. Study was approved by institutional ethical committee. Adults diagnosed with metabolic syndrome were enrolled from the medicine outpatient services. The study procedures were explained in a language understood by each participant, and written informed consent was obtained before enrolment.

Inclusion Criteria

- Adults aged 18–65 years, fulfilling harmonized diagnostic criteria for metabolic syndrome, overweight/obesity according to the prespecified BMI criterion
- Patients willing to participate in the structured lifestyle programme.

- Patients able to attend baseline and 12-week follow-up assessment.
- Patients providing informed consent.

Exclusion Criteria

- Pregnancy or lactation.
- Acute severe medical illness at enrolment.
- Secondary causes of obesity.
- Severe hepatic or renal dysfunction.
- Uncontrolled endocrine disease affecting body weight.
- Current treatment with medications specifically initiated for pharmacological weight reduction.
- Recent bariatric or metabolic surgery.
- Major change in glucose-, lipid-, or blood-pressure-lowering medication during the intervention period when such change precluded meaningful interpretation of the primary outcomes.

Metabolic syndrome was defined according to the harmonized criteria proposed by Alberti et al., requiring any three of five: waist ≥90 cm in men or ≥80 cm in women; triglycerides ≥150 mg/dL or treatment; HDL-C <40 mg/dL in men or <50 mg/dL in women or treatment; systolic BP ≥130 mmHg and/or diastolic BP ≥85 mmHg or antihypertensive treatment; fasting glucose ≥100 mg/dL or treatment for hyperglycaemia. [1] For Asian Indian participants, waist-circumference thresholds of ≥90 cm in men and ≥80 cm in women were applied in accordance with Indian recommendations. [2]

Baseline demographic information, smoking status, comorbidities, ongoing pharmacotherapy, body weight, height, body mass index (BMI), waist circumference, systolic blood pressure, and diastolic blood pressure were documented. BMI was calculated as weight in kilograms divided by height in metres squared. Waist circumference was measured using a non-stretchable measuring tape with the participant standing and breathing normally.

Participants underwent a structured 12-week lifestyle intervention emphasizing an individualized calorie deficit, reduction in refined carbohydrates and added sugars, increased consumption of vegetables and fibre-rich foods, moderation of saturated and trans fats, portion control, and regular physical activity. Dietary recommendations were broadly consistent with principles recommended for Asian Indians with obesity and metabolic risk.[3] Moderate-intensity aerobic physical activity was encouraged on most days of the week, with the goal of achieving approximately 150 minutes or more per week according to individual clinical suitability.

Body weight, BMI, waist circumference, and blood pressure were reassessed after 12 weeks. Venous blood samples were obtained after an overnight fast at baseline and at the end of follow-up. Biochemical assessment included fasting plasma glucose, glycated haemoglobin (HbA1c), total cholesterol, triglycerides, HDL-C, and LDL-C. Participants were categorized according to percentage change in body weight at 12 weeks. Clinically meaningful weight reduction was defined for analysis as loss of ≥5% of baseline body weight. Participants achieving <5% weight reduction formed the comparison category. Medication regimens and changes during follow-up were recorded because they could influence cardiometabolic outcomes.

Statistical Analysis

Data were entered, coded, and analysed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons of continuous variables measured at baseline and after 12 weeks of lifestyle intervention were performed using the paired-samples t-test. Differences in mean changes in anthropometric, haemodynamic, glycaemic, and lipid parameters between participants achieving ≥5% and those achieving <5% weight reduction were assessed using the independent-samples t-test. Categorical variables, including the

proportion of participants achieving resolution of metabolic syndrome between the two weight-loss groups, were compared using the Chi-square test or Fisher's exact test, as appropriate. All statistical tests were two-tailed, and a p-value <0.05 was considered statistically significant.

RESULTS

A total of 175 participants with metabolic syndrome completed the baseline and 12-week assessments. The mean age was 49.2±9.8 years. Ninety-nine (56.57%) participants were male and 76 (43.43%) were female. At baseline, the mean BMI was 31.2±3.7 kg/m² and mean waist circumference was 103.8±9.1 cm. Dyslipidaemia was documented in 118 (67.43%) participants and hypertension in 105 (60.00%). (Refer Table 1)

Table 1. Baseline demographic and clinical characteristics of study participants (n=175)

Characteristic	n (%) / Mean±SD
Age, years	49.2±9.8
Male	99 (56.57)
Female	76 (43.43)
Weight, kg	84.6±11.9
BMI, kg/m²	31.2±3.7
Waist circumference, cm	103.8±9.1
Hypertension	105 (60.00)
Prediabetes	80 (45.71)
Type 2 diabetes mellitus	47 (26.86)
Dyslipidaemia	118 (67.43)
Current smoking	31 (17.71)
Sedentary lifestyle	114 (65.14)

Mean body weight decreased by 4.8 kg, equivalent to 5.7% of the baseline group mean. Waist circumference decreased by 5.7 cm. Mean systolic blood pressure decreased by 7.9 mmHg and diastolic blood pressure by 4.4 mmHg.

Significant improvement was observed across glycaemic and lipid parameters. Fasting plasma glucose decreased by 9.2 mg/dL and HbA1c by 0.27 percentage points. Serum triglycerides decreased by 24.2 mg/dL, while HDL-C increased by 3.3 mg/dL. (Refer table 2)

Table 2. Changes in biochemical parameters after weight reduction (n=175)

Parameter	Baseline	12 weeks	Mean change	p-value*
Fasting plasma glucose, mg/dL	112.8±17.6	103.6±15.4	−9.2±12.9	<0.001
HbA1c, %	6.18±0.62	5.91±0.57	−0.27±0.36	<0.001
Triglycerides, mg/dL	188.4±59.6	164.2±51.7	−24.2±34.8	<0.001
HDL-C, mg/dL	39.2±8.1	42.5±8.4	+3.3±5.6	<0.001
LDL-C, mg/dL	119.6±27.8	112.1±26.3	−7.5±20.1	<0.001
Total cholesterol, mg/dL	197.8±35.9	187.3±33.8	−10.5±28.6	<0.001

At baseline, all 175 participants (100.00%) fulfilled the diagnostic criteria for metabolic syndrome. Increased waist circumference was the most common component, observed in 155 (88.57%) participants, followed by reduced HDL-C/treatment in 134 (76.57%), elevated blood pressure/treatment in 130 (74.29%), elevated fasting glucose/ treatment in 121 (69.14 %), and elevated triglycerides/treatment in 115 (65.71%). After 12 weeks of weight reduction, the prevalence of all metabolic-syndrome components decreased. Increased waist circumference decreased to 130 (74.29%), elevated blood pressure/treatment to 96 (54.86%), elevated fasting glucose/ treatment to 88 (50.29%), elevated triglycerides/treatment to 83 (47.43%), and

reduced HDL-C/treatment to 109 (62.29%). Overall, the proportion fulfilling metabolic syndrome criteria decreased to 115 (65.71%) at 12 weeks, indicating an improvement in metabolic health following weight reduction. (Refer Figure 1)

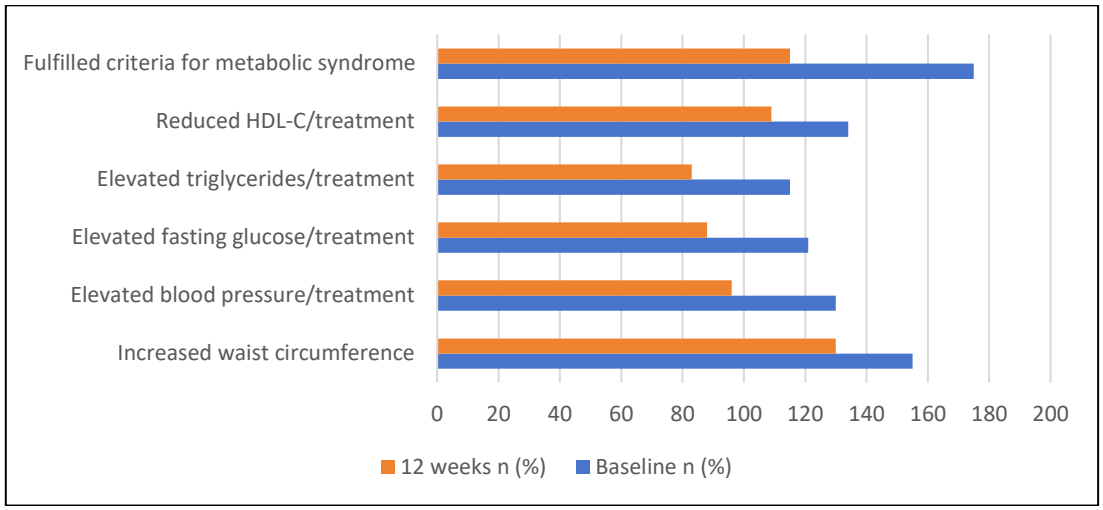


Figure 1 - Prevalence of individual metabolic-syndrome components at baseline and 12 weeks

Ninety-three (53.14%) participants achieved at least 5% reduction in baseline body weight, whereas 82 (46.86%) achieved <5% weight reduction. Improvements in waist circumference, blood pressure, fasting glucose, HbA1c, triglycerides, and HDL-C were greater among participants achieving ≥5% weight reduction. Metabolic syndrome resolved in 42 (45.16%) participants in the ≥5% weight-loss group compared with 18 (21.95%) participants in the <5% weight-loss group. (Refer table 3)

Table 3. Cardiometabolic changes according to achievement of ≥5% body-weight reduction

Parameter	≥5% weight loss (n=93)	<5% weight loss (n=82)	p-value*
Weight change, kg	−7.4±2.1	−1.8±1.2	<0.001
Waist circumference change, cm	−7.8±3.0	−3.2±2.6	<0.001
Systolic BP change, mmHg	−10.6±8.5	−4.7±7.9	<0.001
Diastolic BP change, mmHg	−5.8±5.5	−2.7±5.3	<0.001
Fasting glucose change, mg/dL	−12.9±12.8	−5.0±11.7	<0.001
HbA1c change, %	−0.36±0.35	−0.17±0.31	<0.001
Triglyceride change, mg/dL	−32.8±33.2	−14.5±28.9	<0.001
HDL-C change, mg/dL	+4.4±5.6	+2.0±5.1	0.003
Metabolic-syndrome resolution	42 (45.16)	18 (21.95)	0.001

DISCUSSION

The present study evaluated changes in anthropometric, haemodynamic, and biochemical parameters following a structured weight-reduction programme in adults with metabolic syndrome. Over 12 weeks, mean body weight decreased by 4.8 kg, BMI by 1.8 kg/m², and waist circumference by 5.7 cm. These anthropometric changes were accompanied by reductions in systolic and diastolic blood pressure, fasting plasma glucose, HbA1c, triglycerides, LDL-C, and total cholesterol, together with an increase in HDL-C. Slightly more than half of the participants achieved ≥5% weight reduction, and this subgroup demonstrated greater improvement across several cardiometabolic parameters. At the completion of follow-up, 34.29% of participants no longer fulfilled diagnostic criteria for metabolic syndrome.

Central adiposity is fundamental to the metabolic abnormalities represented within metabolic syndrome. The harmonized definition recognizes waist circumference as one of five major diagnostic components

while allowing ethnic-specific thresholds. [1] This distinction is particularly relevant in Asian Indians because metabolic risk may become apparent at lower BMI and waist circumference than in many Western populations. [2] Misra et al., [2] emphasized the predisposition of Asian Indians to abdominal adiposity and proposed lower BMI and waist-circumference thresholds for identifying cardiometabolic risk. The baseline mean BMI of 31.2 kg/m² and waist circumference of 103.8 cm in the present cohort therefore represented substantial adiposity in an Indian population. The 5.7-cm reduction in waist circumference following intervention is clinically relevant because abdominal-fat reduction is closely linked with improvement in insulin sensitivity and other metabolic abnormalities.

The magnitude of weight reduction observed in the present study is consistent with the principle that moderate short-term weight loss can result in measurable metabolic improvement. In the Diabetes Prevention Program, intensive lifestyle intervention was designed to achieve 7% weight loss together with at least 150 minutes of physical activity per week. [4] Orchard et al., [4] demonstrated that intensive lifestyle intervention reduced the development of metabolic syndrome and increased its resolution among participants with impaired glucose tolerance.

The reduction in waist circumference was greater among individuals achieving ≥5% body-weight loss than among those with lesser weight reduction. This graded association according to achieved weight-loss category is consistent with previous lifestyle-intervention literature. Bo et al., [5] in a randomized 12-month study involving 335 adults with metabolic abnormalities, demonstrated reductions in body weight, waist circumference, inflammatory markers, and several components of metabolic syndrome following structured lifestyle intervention. Their intervention reduced the likelihood of persistent metabolic syndrome and central obesity. The present findings similarly suggest that the magnitude of achieved weight reduction may be an important determinant of the improvement in individual metabolic abnormalities.

Indian evidence also supports intensive lifestyle modification in metabolic syndrome. Yadav et al., [6] conducted a randomized trial among 260 Indian adults with metabolic syndrome and compared a 12-week yoga-based lifestyle programme incorporating dietary intervention with dietary intervention alone. The comprehensive intervention produced greater improvement in waist circumference and metabolic-syndrome risk score, while 45.4% of participants in the yoga-based lifestyle group recovered from metabolic syndrome compared with 32.3% in the dietary-intervention group. [6] The 34.29% overall resolution observed at 12 weeks in the present study lies within a clinically plausible range when considered alongside that trial. Importantly, the comparison should not be interpreted directly because the interventions, study populations, and criteria for analysing recovery were not identical.

Weight reduction was accompanied by meaningful decreases in blood pressure. Mean systolic blood pressure decreased by 7.9 mmHg and diastolic blood pressure by 4.4 mmHg, with larger reductions among participants who lost ≥5% of their baseline body weight. Dietary composition and physical activity may contribute to blood-pressure improvement beyond weight change alone. Azadbakht et al., [10] evaluated a calorie-restricted DASH dietary pattern in 116 patients with metabolic syndrome and demonstrated substantial reductions in systolic and diastolic blood pressure together with improvements in several additional metabolic components. Similarly, Gomez-Huelgas et al., [9] in a three-year lifestyle-intervention trial, observed greater reductions in systolic and diastolic blood pressure among participants receiving intensive Mediterranean-style dietary and exercise counselling than among those receiving usual care. The present findings

therefore accord with evidence that structured lifestyle modification can improve both body weight and haemodynamic risk.

The glycaemic response was also clinically relevant. Fasting plasma glucose decreased by 9.2 mg/dL and HbA1c by 0.27 percentage points over 12 weeks. Participants achieving ≥5% weight loss experienced a larger reduction in fasting glucose and HbA1c than those achieving less weight reduction. Chirinos et al., [8] in the CHARMS randomized controlled trial of 120 adults with metabolic syndrome, demonstrated that lifestyle intervention produced modest but significant weight loss and reduction in fasting glucose, with effects maintained through 12 months. These findings support the biological plausibility of improved glucose regulation following reduction in adiposity and modification of dietary and physical-activity behaviour.

Serum triglycerides decreased by 24.2 mg/dL, whereas HDL-C increased by 3.3 mg/dL. These changes are important because hypertriglyceridaemia and reduced HDL-C represent two defining features of metabolic syndrome. Bo et al., [5] demonstrated significant improvement in hypertriglyceridaemia following structured lifestyle intervention, while the DASH trial by Azadbakht et al., [10] reported decreases in triglycerides and increases in HDL-C.

The greater improvement observed among participants achieving ≥5% weight reduction strengthens the clinical relevance of the anthropometric outcome. Participants reaching this threshold had larger reductions in waist circumference, systolic and diastolic blood pressure, glucose, HbA1c, and triglycerides, as well as a greater increase in HDL-C. Metabolic-syndrome resolution occurred in 45.31% of this group compared with 21.43% among participants losing <5% body weight. Although this comparison cannot establish that weight loss alone caused the improvement because greater adherence to diet and exercise may independently influence metabolic parameters, it supports ≥5% weight loss as a practical short-term therapeutic target.

Lifestyle intervention need not rely on a single dietary pattern. Indian consensus dietary recommendations emphasize reduced intake of refined carbohydrate, added sugar, saturated and trans fats, increased fibre and complex carbohydrates, and greater attention to overall dietary quality. [3] Physical activity complements dietary intervention by increasing energy expenditure, helping preserve lean mass, and improving insulin sensitivity. The Indian trial by Yadav et al., [6] also suggests that combining dietary intervention with physical activity and other structured lifestyle components may offer greater metabolic benefit than dietary advice alone. [6,7] Consequently, weight reduction should be approached as part of comprehensive behavioural modification rather than as an isolated numerical target.

Longer-term studies emphasize the importance of maintaining lifestyle changes after initial weight loss. The three-year study by Gomez-Huelgas et al., [9] demonstrated sustained improvement in several metabolic parameters with intensive lifestyle counselling, while the recently published Enhancing Lifestyles in Metabolic Syndrome randomized clinical trial reported that behavioural lifestyle intervention produced metabolic-syndrome remission in a proportion of participants at both 6 months and 24 months. [12] In that study, 24.8% of the intervention group achieved remission at six months and 27.8% demonstrated sustained remission at 24 months.[12] These data are important because initial weight reduction may be easier to achieve than long-term weight maintenance. Continued follow-up, behavioural reinforcement, self-monitoring, and culturally appropriate dietary and physical-activity strategies are therefore likely to be necessary for sustained benefit.

The study evaluated anthropometric, haemodynamic, glycaemic, and lipid parameters simultaneously using paired measurements obtained before and after a

predefined 12-week lifestyle programme. Assessment according to achievement of ≥5% baseline weight reduction provided clinically interpretable information regarding the association between magnitude of achieved weight loss and cardiometabolic changes.

However, the single-centre design and absence of a concurrent control group limit causal interpretation and external generalisability. Changes observed over time cannot be attributed exclusively to the lifestyle programme or to weight reduction, and regression to the mean and other temporal influences cannot be excluded. The ≥5% and <5% weight-loss groups were defined after follow-up and were not randomized; therefore, differences between them may reflect baseline characteristics, adherence, medication use, or other confounding factors. The 12-week follow-up period does not permit assessment of long-term weight maintenance or sustained metabolic-syndrome resolution.

CONCLUSION

Following 12 weeks of structured lifestyle modification, statistically significant within-participant changes were observed in body weight, BMI, waist circumference, blood pressure, fasting plasma glucose, HbA1c, triglycerides, LDL-C, total cholesterol, and HDL-C among adults with metabolic syndrome. At follow-up, 60 participants (34.29%) no longer fulfilled the diagnostic criteria for metabolic syndrome.

Participants who achieved ≥5% reduction in baseline body weight showed greater changes in several cardiometabolic parameters, and metabolic-syndrome resolution was more frequent in this group than among participants achieving <5% weight reduction. Because the study lacked a concurrent control group and the weight-loss categories were determined after follow-up, these findings demonstrate associations rather than causal effects. Longer controlled studies are required to determine the durability of these changes and the independent contribution of achieved weight reduction.

Declaration

Ethical Approval: Approved

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Conflict of Interest: The authors declare no conflict of interest.

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