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Impact of Exercise-Based Cardiac Rehabilitation on Metabolic Syndrome Parameters: A Cohort Observational Study

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ABSTRACT

Background: Metabolic syndrome (MetS) is a cluster of metabolic disorders associated with an increased risk of cardiovascular disease (CVD). Post-acute coronary syndrome (ACS) patients with MetS experience worse prognosis and functional recovery. Exercise-based cardiac rehabilitation (CR) is a cornerstone intervention that has shown benefits in reducing cardiovascular risk factors and improving metabolic parameters.

Objective: This study aimed to investigate the effects of a supervised 12-week CR program on MetS parameters among patients recovering ACS, in comparison with standard guideline-directed medical therapy alone.

Patients and methods: This prospective observational cohort study was performed at Ain Shams University Hospitals between July and December 2021. The study enrolled 62 patients diagnosed with MetS following ACS. Participants were allocated into two groups: Group A (n = 32) underwent supervised exercise-based CR, while group B (n = 30) received standard medical therapy alone. Assessments conducted at baseline and after the intervention period included waist circumference (WC), fasting blood sugar (FBS), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and blood pressure (BP).

Results: After completing 12 weeks, group A showed marked improvements, characterized by significant decreases in WC by 5.38 cm ($P < 0.001$), FBS by 14 mg/dL ($P = 0.012$), and TG levels by 20.5 mg/dL ($P = 0.008$), accompanied by a notable elevation in HDL-C by 3.5 mg/dL ($P = 0.049$). BP did not change significantly. In contrast, group B demonstrated no meaningful enhancement in MetS-related parameters.

Conclusion: A 12-week supervised exercise-based CR program significantly improved key MetS parameters in post-ACS patients compared to medical therapy alone. These findings underscored the importance of structured CR programs in reducing cardiovascular risks associated with MetS.

Keywords: Cardiac rehabilitation, Metabolic syndrome, Acute coronary syndrome, Exercise therapy, Cardiovascular risk.

INTRODUCTION

Metabolic syndrome (MetS) refers to a group of interrelated metabolic disturbances closely linked to visceral adiposity. These disturbances encompass insulin resistance (IR), central obesity characterized by increased hypertension (HTN), waist circumference (WC), and dyslipidemia manifested by elevated triglycerides (TG) and reduced levels of high-density lipoprotein cholesterol (HDL-C) [1]. Individuals meeting four or more criteria of MetS experience a 3.7-fold greater likelihood of coronary artery disease (CAD) at 5-year follow-up [2].

Considering the established role of MetS as a significant precursor to CAD, recommendations from multiple professional organizations have emphasized the need for intensified strategies aimed at reducing the prevalence of MetS and its individual components [3].

The diagnosis of MetS, after myocardial infarction, carries a worse prognosis and was associated with a worse functional recovery [4].

However, numerous randomized controlled trials (RCTs) have suggested that cardiac rehabilitation (CR) can significantly lower the rates of recurrent cardiac events, decrease cardiovascular and all-cause mortality, and promote favorable ventricular remodeling, particularly after myocardial infarction or heart failure [5]. CR programs incorporating structured exercise training substantially improve exercise tolerance and effectively decrease cardiovascular morbidity and mortality among CAD patients. Furthermore, engaging in CR after myocardial infarction (MI) contributes to fewer hospital readmissions [6, 7].

Accordingly, this study aimed to assess the impact of a supervised 12-week exercise-based CR program versus standard medical therapy alone on MetS parameters in post-acute coronary syndrome (ACS) patients.

PATIENTS AND METHODS

Study design and population: The study was conducted prospectively with an observational design at Ain Shams University Hospitals during the period between July and December 2021.

Inclusion criteria: The study included post-acute coronary syndrome patients aged between 18 and 70 years who had evidence of MetS. A total of 62 patients with post-ACS, encompassing both ST-elevation myocardial infarction (STEMI) and non-ST-elevation ACS (NSTE-ACS), were enrolled in the study.

Patients were allocated into two groups. Group A (case group, n=32) included patients who underwent a supervised exercise-based CR program conducted at the CR Unit of Ain Shams University Hospital. In contrast, group B (control group, n=30) comprised age- and sex-

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matched patients who received guideline-directed medical therapy alone, without participating in the CR intervention.

Case definitions: MetS diagnosis adhered to guidelines provided by the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III). Patients were considered to have MetS if they met at least three of the following clinical criteria. Abdominal obesity was identified by WC measurements of ≥102 cm in males and ≥ 88 cm in females. Hypertriglyceridemia was established by TG concentrations of ≥150 mg/dL. Low HDL-C levels were defined as < 40 mg/dL in men and < 50 mg/dL in women. Elevated BP was classified as systolic values ≥ 130 mmHg or diastolic values ≥ 85 mmHg. High fasting blood sugar was considered present if fasting glucose concentrations were above 110 mg/dL [8].

Study procedures: All participants underwent focused clinical examinations, during which BP was measured twice in both arms. WC was assessed using a flexible measuring tape positioned midway between the lower margin of the rib cage and the iliac crest. Laboratory investigations included fasting blood glucose and TG levels, which were measured from blood samples taken after a 12-hour fasting period. Pharmacotherapy evaluation was performed to ensure that all patients were receiving appropriate anti-ischemic treatment according to the latest European Society of Cardiology guidelines [9].

Cardiac rehabilitation program:

The study was conducted as part of the Phase II CR program at least 14 days after an acute coronary syndrome event. It took place in the Cardiovascular Prevention and Rehabilitation Unit at Ain Shams University Hospitals. Patients first underwent a medical consultation during which their cardiovascular risk factors were stratified, and their current clinical condition was evaluated. The exercise prescription was individualized based on an integration of clinical data and physical examination findings.

Patients in group A were enrolled in a supervised CR program, which involved structured exercise training twice weekly in 40-minute sessions over 12 weeks. Each session included three phases: A warm-up period of 5 to 10 minutes, 20 minutes of aerobic treadmill training, and a cool-down period of 5 to 10 minutes. Throughout the exercise training sessions, patients were continuously monitored and supervised by the medical team.

Patients in group B, the control group, received guideline-directed medical therapy and were advised to adopt conventional lifestyle modifications, including smoking cessation, dietary changes, and increased physical activity.

Follow-up and outcome assessment: All baseline parameters were assessed at the beginning of the study and were reassessed after 12 weeks to evaluate the impact of the interventions.

Ethical considerations: This research protocol received ethical clearance from Ain Shams University's Ethics Committee. Each participant provided written informed consent before inclusion, clearly indicating voluntary agreement to participation and permission for data use, contingent upon maintaining privacy and anonymity. All procedures were conducted strictly in alignment with ethical standards stipulated by the World Medical Association's Declaration of Helsinki governing human research.

Statistical analysis

Data management and statistical evaluation were performed using IBM SPSS Statistics software, version 28 (IBM Corp., Armonk, NY, USA). Quantitative variables were tested for normal distribution using both visual examination and the Shapiro-Wilk normality test. Variables conforming to normal distribution were presented as mean ± standard deviation (SD), while those deviating from normality were summarized as median and interquartile range (IQR). Categorical variables were reported as frequency counts and percentages. The independent samples t-test was utilized for comparing normally distributed continuous variables between groups, whereas non-parametric comparisons employed the Mann-Whitney U test. Categorical data were analyzed using either the Fisher's exact test or Chi-square test. A two-tailed approach was adopted for all statistical analyses, with statistical significance defined by a P-value ≤ 0.05.

RESULTS

No substantial variations detected between groups for age (P = 0.648), gender (P = 0.323), smoking (P = 0.915), diabetes mellitus status (P = 0.915), HTN (P = 0.533), and diagnosis classification (P = 0.321) (Table 1).

Table 1: Demographic data and baseline characteristics of the two studied groups

		Group A (n =32)	Group B (n =30)	P-value
Age (years)	Mean ±SD	56.03 ± 10.29	54.87 ± 9.65	0.648
Gender				
Male	n (%)	23 (71.9)	18 (60.0)	0.323
Female	n (%)	9 (28.1)	12 (40.0)	
Smoking	n (%)	18 (56.2)	14 (46.7)	0.915
DM	n (%)	22 (68.8)	21 (70.0)	0.915
HTN	n (%)	20 (62.5)	21 (70.0)	0.533
Diagnosis				
STEMI	n (%)	20 (62.5)	15 (50.0)	0.321
NSTE-ACS	n (%)	12 (37.5)	15 (50.0)	

n: number, SD: Standard Deviation, DM: Diabetes Mellitus, HTN: Hypertension, STEMI: ST-Elevation Myocardial Infarction, NSTE-ACS: Non-ST-Elevation Acute Coronary Syndrome

No statistically notable variations between groups were observed in systolic blood pressure (P = 0.829), diastolic blood pressure (P = 0.264), WC (P = 0.165), fasting blood glucose levels (P = 0.398), TG levels (P = 0.882), or HDL levels (P = 0.719) (Table 2).

Table 2: Baseline MetS parameters between the studied groups

	Group A (n =32)	Group B (n =30)	P-value
SBP (mmHg)	126.25 ± 14.92	127.17 ± 18.37	0.829
DBP (mmHg)	75.00 ± 12.38	78.17 ± 9.42	0.264
WC (cm)	104.91 ± 7.29	102.17 ±8.07	0.165
FBS (mg/dl)	122.53 ± 30.34	116.93 ± 20.01	0.398
TG (mg/dl)	166.22 ± 41.90	167.90 ± 41.89	0.882
HDL (mg/dl)	39.28 ± 9.51	38.40 ± 9.72	0.719

Data were presented as mean ±SD: standard deviation, HDL: High-Density Lipoprotein, SBP: Systolic Blood Pressure, TG: Triglycerides, WC: Waist Circumference, DBP: Diastolic Blood Pressure, FBS: Fasting Blood Sugar, n: number

Patients in group A exhibited a significantly greater reduction in WC compared to group B (-5.38 [-7.28 – -4.07] cm vs. 1.03 [-1.75 – 2.13] cm, P < 0.001). Additionally, fasting blood sugar showed a markedly greater decrease in group A relative to group B (-14 [-30 – 0.5] mg/dl vs. 4.5 [-17 – 18] mg/dl, P = 0.012). TG levels also demonstrated a significant reduction in group A compared to group B (-20.5 [-33.5 – 4.5] mg/dl vs. 5 [-12 – 13] mg/dl, P = 0.008). Moreover, HDL levels increased significantly in group A relative to group B (3.5 [-2 – 8] mg/dl vs. -1 [-3 – 3] mg/dl, P = 0.049). In contrast, changes in SBP (P = 0.532) and DBP (P = 0.673) were not significant (Table 3).

Table 3: Delta changes after completion of the study

	Group A (n =32)	Group B (n =30)	P-value
SBP (mmHg)	0 (-10 – 10)	0 (-5 – 10)	0.532
DBP (mmHg)	0 (-10 – 10)	0 (-10 – 10)	0.673
WC (cm)	-5.38 (-7.28 – -4.07)	1.03 (-1.75 – 2.13)	**<0.001***
FBS (mg/dl)	-14 (-30 – 0.5)	4.5 (-17 – 18)	**0.012***
TG (mg/dl)	-20.5 (-33.5 – 4.5)	5 (-12 – 13)	**0.008***
HDL (mg/dl)	3.5 (-2 – 8)	-1 (-3 – 3)	**0.049***

Data were presented as median (interquartile range), FBS: Fasting Blood Sugar, SBP: Systolic Blood Pressure, WC: Waist Circumference, TG: Triglycerides, DBP: Diastolic Blood Pressure, HDL: High-Density Lipoprotein, n: number, *: Significant P-value.

DISCUSSION

To our knowledge, no previous studies have evaluated the impact of exercise-based CR programs on MetS specifically in Egyptian patients who have experienced ACS.

At study completion, significant improvements in MetS parameters were observed in group A, specifically WC (-5.38 cm), FBS (-14 mg/dl), TG (-20.5 mg/dl), and HDL-C (+3.5 mg/dl). However, no significant changes were noted in BP within the same group. These results align with evidence from a systematic review and meta-analysis of ten studies involving 17,024 participants, assessing the effectiveness of CR programs on lipid profiles. The analysis demonstrated that CR significantly improved lipid parameters, notably decreasing LDL-C, TC, and TG levels, while significantly increasing HDL-C levels. Additionally, the CR program reduced MetS prevalence by approximately 25%, and exhibited beneficial effects across all MetS components, specifically FBG (−6.42 mg/dL), LDL-C (−11.93 mg/dL), HDL-C (+2.13 mg/dL), and WC (−2.25 cm) [10].

A further meta-analysis investigating the role of CR interventions on blood pressure parameters in individuals with MetS revealed significant improvements, evidenced by notable reductions in average DBP and SBP levels [10]. These findings are different from our results; however, it can be explained by the fact that the initial SBP and DBP measures in our patient population were normal, as the patients were on optimal medical treatment for HTN before enrolment to the study, and that CR succeeded to maintain this normal systolic and diastolic blood pressure.

The beneficial effect of CR on MetS parameters can be explained by the fact that exercise-based CR programs including supervised lifestyle intervention, calorie restriction, and adjunctive therapies are associated with significant reductions in fasting blood glucose, lipid profile, WC, and BP [11]. It is plausible that the moderate WC reduction is due to the synergistic impact of aerobic exercise and moderate dietary caloric limitation, creating an overall negative energy balance that results in weight loss and subsequent reduction of WC [12].

The impact of exercise-based CR on MetS parameters is multifactorial, including supervised exercise training, dietary intervention, weight loss, and adjunctive guideline-directed pharmacotherapy. Engaging regularly in structured moderate-to-vigorous physical activity (PA) may lower the incidence and recurrence of cardiovascular events, an effect potentially mediated by multiple pathways, including anti-atherosclerotic, anti-arrhythmic, anti-ischemic, anti-thrombotic actions, as well as psychological benefits [13].

LIMITATIONS

Several limitations should be acknowledged in this study. The limited sample size might restrict the generalizability of the results. Additionally, the relatively brief 12-week follow-up duration may not adequately reflect the long-term impact of CR programs on metabolic variables and cardiovascular endpoints. Furthermore, since this research was conducted at a single institution, potential selection bias might affect external validity. The lack of randomization may have introduced confounding factors, as patients who participated in the CR program may have had different baseline characteristics or motivation levels compared to those who did not. Lastly, adherence to lifestyle modifications in the control group was based on self-reported measures, which could introduce reporting bias.

CONCLUSION

A structured, supervised 12-week exercise-based CR program resulted in significant improvement of essential MetS parameters among post-ACS patients compared to medical treatment alone. These outcomes underscored the importance of structured CR interventions in reducing cardiovascular risks associated with MetS.

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Conflict of Interest: Nil.

REFERENCES

1. **Tariq H, Nayudu S, Akella S *et al.* (2016)**: Non-Alcoholic Fatty Pancreatic Disease: A Review of Literature. Gastroenterology Res., 9: 87-91.
2. **Sattar N, Gaw A, Scherbakova O *et al.* (2003)**: Metabolic syndrome with and without C-reactive protein as a predictor of coronary heart disease and diabetes in the West of Scotland Coronary Prevention Study. Circulation, 108: 414-9.
3. **Sperling L, Mechanick J, Neeland I *et al.* (2015)**: The CardioMetabolic Health Alliance: Working Toward a New Care Model for the Metabolic Syndrome. J Am Coll Cardiol., 66: 1050-67.
4. **Caminiti G, Volterrani M, Marazzi G *et al.* (2009)**: Metabolic syndrome predicts lower functional recovery in female but not in male patients after an acute cardiac event. Int J Cardiol., 135: 296-301.
5. **Lawler P, Filion K, Eisenberg M (2011)**: Efficacy of exercise-based cardiac rehabilitation post-myocardial infarction: a systematic review and meta-analysis of randomized controlled trials. Am Heart J., 162: 571-84.e2.
6. **Leon A, Franklin B, Costa F *et al.* (2005)**: Cardiac rehabilitation and secondary prevention of coronary heart disease: an American Heart Association scientific statement from the Council on Clinical Cardiology (Subcommittee on Exercise, Cardiac Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity), in collaboration with the American association of Cardiovascular and Pulmonary Rehabilitation. Circulation, 111: 369-76.

7. **Dunlay S, Pack Q, Thomas R *et al.* (2014)**: Participation in cardiac rehabilitation, readmissions, and death after acute myocardial infarction. Am J Med., 127: 538-46.

8. **Huang P (2009)**: A comprehensive definition for metabolic syndrome. Dis Model Mech., 2: 231-7.

9. **Virani S, Newby L, Arnold S *et al.* (2023)**: 2023 AHA/ACC/ACCP/ASPC/NLA/PCNA Guideline for the Management of Patients With Chronic Coronary Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines. Circulation, 148: e9-e119.

10. **Sadeghi M, Salehi-Abargouei A, Kasaei Z *et al.* (2016)**: Effect of cardiac rehabilitation on metabolic syndrome and its components: A systematic review and meta-analysis. J Res Med Sci., 21: 18.

11. **Grundy S, Stone N, Bailey A *et al.* (2019)**: 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/ APhA/ASPC/NLA/PCNA Guideline on the Management of Blood Cholesterol: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation, 139: e1082-e143.

12. **Jakicic J, Rogers R, Davis K *et al.* (2018)**: Role of Physical Activity and Exercise in Treating Patients with Overweight and Obesity. Clin Chem., 64: 99-107.

13. **Powell K, Thompson P, Caspersen C *et al.* (1987)**: Physical activity and the incidence of coronary heart disease. Annu Rev Public Health, 8: 253-87.