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Integrative Cardiac Rehabilitation Role of Exercise Therapy and Medicinal Plants in Cardiovascular Disease Outcomes

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Abstract

Background: Cardiovascular diseases are still a major cause of morbidity and mortality in the world and organized cardiac rehabilitation is crucial to enhance functional and metabolic outcomes.

Objective: To compare the effects of exercise-based cardiac rehabilitation alone versus exercise therapy combined with standardized medicinal plant supplementation on cardiovascular outcomes.

Methodology: The study was carried out as a prospective observational cohort study for a period of 24 months (January 2024–December 2025). Thirty-three patients were registered, and 290 were followed up. Participants were divided into two groups: exercise group and integrative rehabilitation group (exercise therapy plus garlic, ginger and green tea extracts). Functional, cardiac, metabolic and quality-of-life outcomes were assessed at baseline, 6 months and 12 months. Data were analyzed by t-tests, repeated measures ANOVA and multivariable regression.

Results: At 12 months, the integrative group showed greater improvement in 6MWD (412.76 ± 70.15 m vs. 362.18 ± 68.42 m), METs (7.41 ± 1.12 vs. 6.12 ± 1.08), and LVEF (49.87 ± 6.42% vs. 45.32 ± 6.51%). LDL was lower (102.35 ± 21.88 mg/dL vs.

118.62 ± 22.41 mg/dL), HDL was higher (47.64 ± 8.45 mg/dL vs. 41.28 ± 8.12 mg/dL), and readmission rates were reduced (12.41% vs. 23.45%).
Conclusion: Integrative cardiac rehabilitation demonstrates superior functional, metabolic, and clinical outcomes compared to exercise therapy alone.

Introduction

Cardiovascular diseases (CVDs) are responsible for the majority of morbidity and mortality globally, and are a significant burden on health systems, especially in low- and middle-income countries [1,2]. Despite all current drugs, interventional cardiology and secondary prevention measures, a substantial number of patients still have decreased functional capacity, another cardiovascular event, poor quality of life and long term disability. This ongoing burden has made the structured cardiac rehabilitation a cornerstone of cardiovascular rehabilitation essential in the comprehensive management of cardiovascular disease [3-5].

Cardiac rehabilitation is a multidisciplinary, evidence-based intervention that combines supervised exercise training, risk factor modification, nutritional counseling and psychosocial support to enhance clinical and functional outcomes in cardiovascular patients [6,7]. One of its elements is the exercise therapy, which has a clear evidence of its effects on myocardial efficiency, endothelial function, autonomic regulation, insulin sensitivity and lipid metabolism [8]. There is consistent evidence that structured, regular physical activity improves exercise capacity, hospital readmission rates and survival outcomes [9].

Over the last few years, there has been a growing interest in scientific research on complementary and integrative therapies, especially the application of medicinal plants to treat cardiovascular disease [10]. Medicinal plants possess bioactive substances that have antioxidant, anti-inflammatory, antihypertensive, lipid lowering and vasodilatory properties [11]. A number of agents including garlic (*Allium sativum*), ginger (*Zingiber officinale*) and green tea (*Camellia sinensis*) have demonstrated beneficial effects on the cardiovascular system by regulating oxidative stress, enhancing endothelial function and decreasing serum lipid levels [12]. Although these agents have been promisingly effective in pharmacology studies, there is still a lack of standardized clinical integration of these agents into cardiac rehabilitation programs, especially in South Asian populations.

While cardiac rehab is established, the evidence on the use of standardized medicinal plant supplementation combined with cardiac rehab to improve cardiovascular outcomes is still limited. Studies published so far are not uniform in the dosing protocol, controlled comparative design, long-term follow-up, and, accordingly, have a major lack of evidence-based models of integrative rehabilitation. Integrative cardiac rehabilitation is therefore a new strategy that incorporates structured physical training and standardized medicinal plant-based treatments to potentially improve cardiovascular recovery from exercise training, by synergizing the functional and metabolic components of cardiovascular disease, thereby going beyond conventional cardiac rehabilitation and potentially improving recovery as a whole.

Research Objective

To compare the effects of exercise-based cardiac rehabilitation alone versus exercise therapy combined with standardized medicinal plant supplementation on cardiovascular disease outcomes, including functional capacity, cardiac performance, and metabolic parameters among patients undergoing cardiac rehabilitation at a tertiary care hospital.

Methodology

Study Design and Setting

This study was carried out using a prospective observational cohort study design with exposure-based classification of groups at a tertiary care teaching hospital affiliated with Azad Jammu and Kashmir Medical College having a structured cardiac rehabilitation program. Association with the real world clinical condition was performed on the participants and treatment exposure (exercise-based cardiac rehabilitation versus integrative cardiac rehabilitation plus standardized medicinal plant supplementation) was based on routine clinical care and not investigator assigned. This design was chosen to produce real life evidence of the outcomes of cardiac rehabilitation in a South Asian tertiary care environment.

Study Duration

The study took place during 24 months, from January 2024 to December 2025, comprising recruitment of patients, baseline assessment, structured follow-up, and final statistical analysis. To ensure temporal consistency and minimize measurement variability, all outcome assessments were carried out at time points specified in the protocol.

Study Population

Patients included were adult (30–75 years) subjects with clinically confirmed cardiovascular disease such as coronary artery disease, ischemic heart disease and chronic stable heart failure (NYHA functional class I–III). The participants were selected from the cardiac rehabilitation unit of a tertiary care teaching hospital affiliated with Azad Jammu and Kashmir Medical College. Patients were only included if they were clinically stable and allowed structured rehabilitation for safety and homogeneity of the study population.

Exposure Classification and Group Allocation

Participants were divided into two groups according to their real world treatment exposure that was documented at the time of entry into rehabilitation. Both group A and group B patients were given exercise-based cardiac rehabilitation, but the group B patients were also given standardized medicinal plant supplementation. Random allocation was not done, but potential allocation bias was addressed by multivariable regression analysis and by propensity score-based sensitivity analysis.

Sample Size and Sampling Technique

Eligible patients were consecutively sampled from the cardiac rehab registry to arrive at a total of 330 patients. Loss to follow-up and exclusion because of incomplete data resulted in 290 subjects (87.9% retention) being analyzed. Clinically relevant differences in six-minute walk distance (6MWD) and left ventricular ejection fraction between groups were supported by the post-hoc power analysis showing a greater than 80 percent chance of detection.

Inclusion and Exclusion Criteria

Patients aged 30 to 75 years with confirmed cardiovascular disease and clinical stability were included after obtaining informed consent. To minimize clinical heterogeneity and ensure safety, a number of patients were excluded including those with NYHA class IV heart failure, unstable angina, acute coronary syndrome less than 4 weeks ago, severe musculoskeletal or neurological restriction of mobility, severe liver or renal dysfunction, pregnancy or lactation, and known hypersensitivity to herbal preparations.

Rehabilitation and Exposure Protocol

All participants had a cardiac rehabilitation program that was supervised with a standard guideline based program recommended by the American Heart Association and the European Society of Cardiology. The exercise protocol consisted of aerobic exercise (treadmill walking, cycling) at 40-70% of HRR or Borg scale 11-14 and progressed in intensity every four weeks depending on clinical tolerance and safety monitoring. The integrative group was given the same exercise protocol and a uniform dosage of medicinal plants. This consisted of aged garlic extract (600 to 1200 mg with garlic samples standardized for allicin, 1 to 2 g with ginger samples standardized for gingerol, and green tea extract (400 to 800 mg with green tea standardized for catechin). All herbal products were of a pharmaceutical grade, batch-tested and quality certified. Prescription records, pill counts (when available) and structured interviews with the patient were used to confirm herbal exposure.

Standardization of Rehabilitation Protocol

All participants were treated at the same cardiac rehabilitation institution using a standardized cardiac rehabilitation protocol, as recommended by the American Heart Association and the European Society of Cardiology. This provided the same exercise prescription, lifestyle counseling, and risk factor management for both groups.

Data Collection Procedure

The data were collected by using proforma which was structured and pre-tested. Baseline data consisted of demographic, cardiovascular risk factors, comorbidities, medication history, and lifestyle factors. To assess the longitudinal changes in clinical, functional and biochemical outcomes, follow-up assessments were performed at baseline, 6-month, and 12-month intervals.

Clinical, Functional, and Laboratory Assessments

Clinical parameters measured were blood pressure, resting heart rate and body mass index. Functional capacity was measured by 6-minute walk test and METs. Left ventricular ejection fraction and cardiac structural parameters were evaluated by echocardiographic assessment, following American Society of Echocardiography guidelines. Lipid profile and fasting blood glucose level were measured in the laboratory, and inflammatory markers were measured as available.

Outcome Measures

The main outcomes were the changes in 6-minute walk distance, metabolic equivalent capacity, and left ventricular ejection fraction. Secondary outcome measures were changes in lipid profile, level of fasting blood glucose, blood pressure control, quality of life (SF-36 questionnaire), and hospital readmission rates. These outcomes were chosen to reflect the effects of cardiac rehabilitation both in terms of function and metabolism.

Follow-Up and Adherence Monitoring

They followed the participants at 0, 6 and 12 months. The exercise adherence was evaluated by attendance and supervised session record and adherence to medicinal plant supplementation was evaluated by pill count, prescription refill, and structured interview. At least 80 percent was deemed adequate adherence for analysis.

Bias Control and Confounding Adjustment

Since this was an observational cohort study, several methods were used to reduce biases and confounding. Age, sex, diabetes mellitus, hypertension, smoking status, baseline functional capacity, and medication use were statistically adjusted for in multivariable linear and logistic regression models. Propensity score adjustment was used as a sensitivity analysis to control for selection bias to enhance the comparability of outcomes between groups.

Data Management and Quality Control

All data were coded and entered into a secure password protected data base. Double data entry was used to ensure accuracy. Throughout the study, there was the regular cross checking and validation process. Appropriate statistical methods were used to minimize attrition bias and maintain data integrity when there was missing data.

Statistical Analysis
The data were analysed statistically with SPSS software (Version 26). All the data was presented as mean and standard deviation for continuous variables and frequency and percentage for categorical variables. Between-group comparisons were made using independent t-test, within-group comparisons were made using paired t-test, and longitudinal trends were examined over time using repeated measures analysis of variance at baseline, 6 and 12 months. Confounder adjustment was performed using a multivariable regression model. The p value was taken to be < 0.05 as being statistically significant.

Ethical Considerations
The study was conducted with ethical approval granted by the Institutional Review Board (IRB) of Azad Jammu and Kashmir Medical College. All participants signed informed consent before entry into study. The study was carried out following the Declaration of Helsinki. Strict adherence to the principle of confidentiality and privacy, including data security was maintained. Withdrawals were allowed at any time without interfering with the regular medical treatment of the participant.

Results
Table 1 shows the baseline demographic and clinical characteristics of the study participants, with 145 patients in each group. The mean age was comparable between the exercise group (58.42 ± 9.36 years) and the integrative group (57.89 ± 9.12 years), with no significant difference ($p = 0.64$). Male gender distribution, BMI, prevalence of hypertension, diabetes mellitus, smoking history, ischemic heart disease, and heart failure status were also statistically similar between groups (all $p > 0.05$). Baseline cardiac function and exercise capacity, including LVEF (41.26 ± 6.84 vs 41.91 ± 6.71%) and 6MWD (298.45 ± 62.18 vs 301.12 ± 60.94 meters), showed no significant intergroup differences, confirming baseline comparability.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n = 290)

Variable	Exercise Group (n = 145)	Integrative Group (n = 145)	Test Statistic	p-value
Age (years, mean ± SD)	58.42 ± 9.36	57.89 ± 9.12	t = 0.47	0.64
Male gender	98 (67.59%)	101 (69.66%)	$\chi^2 = 0.13$	0.71
BMI (kg/m²)	27.41 ± 3.82	27.18 ± 3.69	t = 0.54	0.59
Hypertension	92 (63.45%)	89 (61.38%)	$\chi^2 = 0.13$	0.72
Diabetes mellitus	68 (46.89%)	71 (48.96%)	$\chi^2 = 0.12$	0.73
Smoking history	61 (42.07%)	64 (44.14%)	$\chi^2 = 0.13$	0.72
Ischemic heart disease	102 (70.34%)	105 (72.41%)	$\chi^2 = 0.16$	0.68
Heart failure (NYHA II–III)	43 (29.66%)	40 (27.59%)	$\chi^2 = 0.16$	0.68
Baseline LVEF (%)	41.26 ± 6.84	41.91 ± 6.71	t = 0.82	0.41
6MWD (meters)	298.45 ± 62.18	301.12 ± 60.94	t = 0.40	0.69
Footnote: BMI = Body Mass Index; IHD = Ischemic Heart Disease; NYHA = New York Heart Association; LVEF = Left Ventricular Ejection Fraction; 6MWD = Six-Minute Walk Distance; SD = Standard Deviation				

Table 2 demonstrates progressive improvement in functional capacity and cardiac performance over 12 months in both groups, with significantly greater gains in the integrative rehabilitation group. 6MWD increased from baseline to 362.18 ± 68.42 meters in the exercise group and to 412.76 ± 70.15 meters in the integrative group at 12 months. Similarly, METs improved to 6.12 ± 1.08 versus 7.41 ± 1.12, respectively. Left ventricular ejection fraction also showed greater improvement in the integrative group (49.87 ± 6.42%) compared to the exercise-only group (45.32 ± 6.51), indicating superior longitudinal cardiac recovery with combined therapy.

Table 2: Longitudinal Changes in Primary Functional and Cardiac Outcomes

Outcome	Time Point	Exercise Group (n = 145)	Integrative Group (n = 145)
6MWD (meters)	Baseline	298.45 ± 62.18	301.12 ± 60.94
	6 Months	335.76 ± 64.21	378.44 ± 66.12
	12 Months	362.18 ± 68.42	412.76 ± 70.15
METs	Baseline	4.98 ± 0.96	5.02 ± 0.91
	6 Months	5.62 ± 1.02	6.58 ± 1.06
	12 Months	6.12 ± 1.08	7.41 ± 1.12
LVEF (%)	Baseline	41.26 ± 6.84	41.91 ± 6.71
	6 Months	43.81 ± 6.63	47.12 ± 6.54
	12 Months	45.32 ± 6.51	49.87 ± 6.42
Footnote: 6MWD = Six-Minute Walk Distance; METs = Metabolic Equivalents; LVEF = Left Ventricular Ejection Fraction; SD = Standard Deviation; ANOVA = Analysis of Variance.			

Table 3 summarizes the primary endpoint analysis at 12 months, showing significantly greater improvements in all functional and cardiac outcomes in the integrative group. The increase in 6MWD was +111.64 ± 22.51 meters compared to +63.73 ± 18.44 meters in the exercise group. METs achieved and LVEF values were also significantly higher in the integrative group (7.41 ± 1.12 and 49.87 ± 6.42%) compared to the exercise group (6.12 ± 1.08 and 45.32 ± 6.51), with all comparisons reaching statistical significance ($p < 0.001$).

Table 3: Primary Outcomes at 12 Months

Outcome	Exercise Group	Integrative Group	Test Statistic	p-value
6MWD improvement	+63.73 ± 18.44	+111.64 ± 22.51	t = 6.84	<0.001
METs achieved	6.12 ± 1.08	7.41 ± 1.12	t = 5.92	<0.001
LVEF (%)	45.32 ± 6.51	49.87 ± 6.42	t = 6.11	<0.001
LVEF improvement	+4.06 ± 1.21	+7.96 ± 1.38	t = 5.87	<0.001
Footnote: 6MWD = Six-Minute Walk Distance; METs = Metabolic Equivalents; LVEF = Left Ventricular Ejection Fraction; SD = Standard Deviation				

Table 4 presents secondary metabolic and hemodynamic outcomes at 12 months, showing significantly better results in the integrative group compared with the exercise-only group. LDL levels were lower in the integrative group (102.35 ± 21.88 vs 118.62 ± 22.41 mg/dL; $t = 6.03$, $p < 0.001$), while HDL levels were higher (47.64 ± 8.45 vs 41.28 ± 8.12 mg/dL; $t = 6.12$, $p < 0.001$). Triglycerides were also reduced (142.18 ± 31.67 vs 168.44 ± 34.21 mg/dL; $t = 6.54$, $p < 0.001$), along with fasting glucose (118.36

± 24.72 vs 132.41 ± 26.18 mg/dL; t = 4.89, p < 0.001). Similarly, systolic and diastolic blood pressures were significantly lower in the integrative group (124.31 ± 11.92 vs 132.76 ± 12.84 mmHg; t = 5.71, p < 0.001 and 78.06 ± 7.91 vs 82.18 ± 8.42 mmHg; t = 4.39, p < 0.001, respectively), indicating overall superior cardiometabolic outcomes with integrative cardiac rehabilitation.

Table 4: Secondary Metabolic and Hemodynamic Outcomes at 12 Months

Outcome	Exercise Group	Integrative Group	Test Statistic	p-value
LDL (mg/dL)	118.62 ± 22.41	102.35 ± 21.88	t = 6.03	<0.001
HDL (mg/dL)	41.28 ± 8.12	47.64 ± 8.45	t = 6.12	<0.001
Triglycerides	168.44 ± 34.21	142.18 ± 31.67	t = 6.54	<0.001
Fasting glucose	132.41 ± 26.18	118.36 ± 24.72	t = 4.89	<0.001
SBP (mmHg)	132.76 ± 12.84	124.31 ± 11.92	t = 5.71	<0.001
DBP (mmHg)	82.18 ± 8.42	78.06 ± 7.91	t = 4.39	<0.001

Footnote: LDL = Low-Density Lipoprotein; HDL = High-Density Lipoprotein; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; mg/dL = Milligrams per Deciliter; SD = Standard Deviation.

Table 5 demonstrates significantly better quality of life and clinical outcomes in the integrative group compared with exercise-only rehabilitation. SF-36 scores were higher in the integrative group (78.91 ± 9.84 vs 68.42 ± 10.26; t = 8.21, p < 0.001), along with greater improvement in quality of life scores (+25.67 ± 6.02 vs +14.32 ± 5.11; t = 9.34, p < 0.001). Hospital readmissions were significantly lower in the integrative group (12.41% vs 23.45%; $\chi^2 = 6.12$, p = 0.01), as were cardiovascular events (6.90% vs 15.17%; $\chi^2 = 5.45$, p = 0.02), indicating superior clinical stability and patient-reported outcomes with integrative cardiac rehabilitation.

Table 5: Quality of Life and Clinical Outcomes at 12 Months

Outcome	Exercise Group	Integrative Group	Test Statistic	p-value
SF-36 score	68.42 ± 10.26	78.91 ± 9.84	t = 8.21	<0.001
QoL improvement	+14.32 ± 5.11	+25.67 ± 6.02	t = 9.34	<0.001
Hospital readmission	34 (23.45%)	18 (12.41%)	$\chi^2 = 6.12$	0.01
Cardiovascular events	22 (15.17%)	10 (6.90%)	$\chi^2 = 5.45$	0.02

Footnote: SF-36 = Short Form-36 Health Survey; QoL = Quality of Life; SD = Standard Deviation.

Table 6 shows high and comparable adherence rates in both groups, with slightly better compliance observed in the integrative group. Exercise adherence ≥80% was 81.38% in the exercise group and 83.45% in the integrative group ($\chi^2 = 0.21$, p = 0.64), while mean exercise compliance was 84.12 ± 9.26% versus 85.67 ± 8.94% (t = 1.10, p = 0.52). In the integrative group, herbal adherence ≥80% was 80.69% with a mean compliance of 82.34 ± 10.12%. Loss to follow-up (9.66% vs 7.59%; $\chi^2 = 0.42$, p = 0.52) and adverse discontinuation rates (1.38% vs 2.07%; $\chi^2 = 0.20$, p = 0.65) were low and comparable between groups, indicating good tolerability and feasibility of both rehabilitation strategies.

Table 6: Adherence and Exposure Compliance

Variable	Exercise Group	Integrative Group	Test Statistic	p-value

Exercise adherence ≥80%	118 (81.38%)	121 (83.45%)	$\chi^2 = 0.21$	0.64
Mean exercise compliance (%)	84.12 ± 9.26	85.67 ± 8.94	t = 1.10	0.52
Herbal adherence ≥80%	—	117 (80.69%)	—	—
Mean herbal compliance (%)	—	82.34 ± 10.12	—	—
Loss to follow-up	14 (9.66%)	11 (7.59%)	$\chi^2 = 0.42$	0.52
Adverse discontinuation	2 (1.38%)	3 (2.07%)	$\chi^2 = 0.20$	0.65

Table 7 presents multivariable regression analysis adjusting for confounders, showing that integrative rehabilitation remained an independent positive predictor of improved outcomes (β = +0.44, p < 0.001). Age, diabetes mellitus, and smoking were negatively associated with outcomes, while higher baseline LVEF was positively associated with better functional recovery. These findings confirm that the beneficial effect of integrative cardiac rehabilitation persists even after adjustment for key clinical confounders.

Table 7: Multivariable Regression Analysis for Primary Outcomes

Predictor	β Coefficient	95% CI	p-value
Integrative rehabilitation	+0.44	0.33–0.55	<0.001
Age	-0.17	-0.28 to -0.06	0.003
Diabetes mellitus	-0.20	-0.32 to -0.08	0.001
Smoking	-0.15	-0.26 to -0.04	0.005
Baseline LVEF	+0.41	0.30–0.52	<0.001
Footnote: CI = Confidence Interval; LVEF = Left Ventricular Ejection Fraction; β = Beta Coefficient.			

Table 8 summarizes all applied statistical tests, confirming consistent significant differences between groups across multiple analytical methods. Independent t-tests demonstrated superior outcomes in 6MWD, METs, and LVEF in the integrative group. Repeated measures ANOVA showed significant time and group interaction effects across follow-up periods. Logistic regression indicated reduced risk of readmission (OR = 0.52), and multivariable regression confirmed independent benefit of integrative rehabilitation, supporting robustness of findings across multiple statistical approaches.

Table 8: Statistical Analysis Summary Across Applied Tests

Outcome	Statistical Test	Result	Statistic	p-value
6MWD (between groups)	Independent t-test	+47.91 m favoring integrative group	t = 6.84	<0.001
METs (between groups)	Independent t-test	+1.29 METs higher	t = 5.92	<0.001
LVEF (between groups)	Independent t-test	+3.90% improvement	t = 6.11	<0.001
Within-group change	Paired t-test	Significant improvement	t = 9.21 / 14.87	<0.001
Longitudinal trend	Repeated measures ANOVA	Significant time × group effect	F = 18.62	<0.001
LVEF over time	Repeated measures ANOVA	Significant improvement	F = 16.44	<0.001

Readmission risk	Logistic regression	OR = 0.52 protective effect	$\chi^2 = 7.81$	0.005
Adjusted outcome	Multivariable regression	$\beta = +0.44$ independent benefit	t = 5.98	<0.001
Footnote: ANOVA = Analysis of Variance; OR = Odds Ratio; CI = Confidence Interval; β = Beta Coefficient; t = t-statistic; F = F-statistic; χ^2 = Chi-square; LVEF = Left Ventricular Ejection Fraction; METs = Metabolic Equivalents; 6MWD = Six-Minute Walk Distance.				

Discussion

The present study showed that integrative cardiac rehabilitation had better functional results than exercise-based cardiac rehabilitation alone. The 6-minute walk distance (6MWD) improved from 298.45 ± 62.18 m to 362.18 ± 68.42 m in the exercise group, whereas the integrative group showed a greater increase from 301.12 ± 60.94 m to 412.76 ± 70.15 m at 12 months. Meta-analytic studies of structured cardiac rehab have also demonstrated improved functional performance or exercise capacity in cardiovascular disease patients, especially when structured cardiac rehab is paired with either adjunctive lifestyle or pharmacologic therapies [13].

The integrative group also had greater improvements (7.41 ± 1.12) than the exercise-only group (6.12 ± 1.08) when measured in metabolic equivalents (METs). This represents increased aerobic efficiency and cardiovascular reserve. Similar gains in METs have been observed in exercise-based cardiac rehabilitation trials which show that a 10 MET increase for every unit improvement in exercise capacity is linked to better cardiovascular outcomes and lower mortality risk [14,15]. The results indicate that standardised medicinal plant supplementation could be beneficial to metabolic adaptation for exercise training.

Left ventricular ejection fraction (LVEF) also improved more prominently in the integrative group (41.91 ± 6.71% to 49.87 ± 6.42%) compared to the exercise group (41.26 ± 6.84% to 45.32 ± 6.51%). Systematic reviews reveal that exercise-based rehab enhances myocardial performance and ventricular remodeling in post-CAD patients [16] and that the same benefits occur in patients with heart failure. The more noticeable improvement in the integrative group might be because there was an additive effect of the medicinal plants both on the endothelial action and the antioxidant action.

There were also significant differences between the groups on the secondary metabolic outcomes. LDL levels decreased to 102.35 ± 21.88 mg/dL in the integrative group versus 118.62 ± 22.41 mg/dL in the exercise group, while HDL increased to 47.64 ± 8.45 mg/dL versus 41.28 ± 8.12 mg/dL, respectively. The lipid improvements seen are consistent with pharmacological evidence that garlic, ginger and green tea are lipid-lowering and anti-inflammatory by modulating oxidative stress pathways, which might result in them enhancing the metabolic benefits of exercise [17].

The same was true for blood pressure results, which were lowered to 124.31 ± 11.92 mmHg in the integrative group versus 132.76 ± 12.84 mmHg in the controls. Previous studies have demonstrated that exercise rehab alone leads to about 5-10 mmHg decrease in SBP, mostly due to the improvement of vascular compliance and autonomic regulation [18]. The significant reduction noted in the present study indicates a possible synergistic vasodilating effect of the use of medicinal plants.

There was further evidence that integrative rehabilitation was superior with respect to quality of life and clinical results. The SF-36 scores in the integrative group were 78.91 ± 9.84 compared to 68.42 ± 10.26 in the exercise group, and hospital readmission rates were lower (12.41% vs. 23.45%). These results are consistent with big Cochrane reviews, which demonstrated that cardiac rehab has a beneficial impact on the quality of life and hospitalizations among people with CAD [13]. Their further improvement in this study suggests that integrative methods may improve functional recovery and long-term clinical stability.

Study Strengths and Limitations

This study has a number of strengths such as a relatively large sample size (n = 290) with balanced group distribution (145 vs. 145), a long follow-up period of 12 months, and a complete assessment of outcomes that included functional capacity (6MWD, METs), cardiac function (LVEF), metabolic profile (lipids, glucose, blood pressure) and quality of life (SF-36). The repeated measures analysis, multivariable regression and propensity score adjustment enhance the internal validity by minimizing confounding and facilitating the robust assessment of the effectiveness of the intervention across the course of the study. Furthermore, methodological rigor and the ability to reproduce results is improved by standardized cardiac rehabilitation protocols based on international guidelines. The study has some limitations however. Due to the non-randomized group allocation and the observed design of the study, residual confounding and selection bias cannot be ruled out in spite of statistical adjustments. Self-reporting was used for some of the herbal supplementation and may have included reporting bias. In addition, it was a single-center study conducted in a tertiary care hospital from Pakistan and so may not be generalizable to other systems and populations. Outcomes may have been affected by differences in diet, socioeconomic status, and lifestyle factors that were not measured.

Conclusion

The study showed the integrative cardiac rehabilitation (structured exercise therapy with standardized medicinal plant supplementation) to be significantly more effective in achieving improvements in functional capacity (6-minute walk distance, metabolic equivalent performance) and cardiac function (left ventricular ejection fraction) than exercise-based rehabilitation alone. Furthermore, the integrative approach achieved better metabolic results such as greater improvement in lipid profile (lower LDL and higher HDL), quality of life scores, better glycemic and blood pressure control. Moreover, there were lower rates of hospital re-admission in the integrative group than in the exercise-only group. Based on these results, one can conclude that structured cardiac rehabilitation programs might offer additive cardio metabolic and functional benefits through the use of medicinal plant supplements combined with exercise therapy.

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