

Functional Outcomes and Rehabilitation Strategies in Patients with Rare Cardiomyopathies undergoing Joint Replacement.

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Abstract:

Background: Patients with rare cardiomyopathies such as restrictive, arrhythmogenic right ventricular, and left ventricular non-compaction types pose unique perioperative challenges during joint replacement surgeries. Cardiac dysfunction, rhythm disturbances, and limited exercise tolerance increase the risk of complications and slow rehabilitation progress. With rising joint arthroplasty rates in patients with cardiac comorbidities, developing structured, evidence-based rehabilitation strategies in tertiary care settings is vital for ensuring both cardiac safety and optimal functional recovery.

Aims and Objectives: This study aimed to evaluate the safety, feasibility, and outcomes of a tailored rehabilitation program for patients with rare cardiomyopathies undergoing joint replacement. Objectives included assessing improvement in functional mobility, cardiovascular tolerance to exercise, and incidence of postoperative cardiac or orthopaedic complications.

Materials and Methods: A prospective observational study was conducted at a tertiary care center over 18 months, including 50 patients aged 40–75 years diagnosed with rare cardiomyopathies and scheduled for elective hip or knee arthroplasty. Preoperative optimization included echocardiographic assessment, medication adjustment, and anaesthetic risk stratification. Postoperative rehabilitation was initiated within 48–72 hours using a stepwise protocol starting with isometric quadriceps exercises, incentive spirometry, and gradual ambulation under continuous cardiac monitoring. Data were analysed for functional outcomes (6-minute walk distance, Barthel Index, and joint range of motion) and cardiovascular events during the 12-week follow-up.

Results: Out of 50 patients, 32 (64%) had restrictive cardiomyopathy, 10 (20%) arrhythmogenic right ventricular cardiomyopathy, and 8 (16%) left ventricular non-compaction. Mean ejection fraction was $42 \pm 6\%$. Early mobilization was achieved in 44 patients (88%), while 6 (12%) required delayed rehabilitation due to transient hypotension or arrhythmias. The mean 6-minute walk distance improved from 110 ± 35 m at baseline to 285 ± 60 m at 12 weeks ($p < 0.001$). The Barthel Index improved from 55 ± 10 to 90 ± 8 . Minor cardiac events (asymptomatic bradycardia, transient tachycardia) occurred in 8% of cases, with no mortality or major decompensation. Mean hospital stay was 8.6 ± 2.1 days.

Discussion: Individualized, cardiologist-supervised rehabilitation significantly enhanced postoperative recovery without compromising cardiac safety. Early, low-intensity mobilization with hemodynamic monitoring proved feasible and beneficial in tertiary care settings. A multidisciplinary approach integrating orthopaedics, cardiology, and physiotherapy teams is crucial for optimizing outcomes in this high-risk population.

Keywords: Cardiomyopathy, Joint replacement, Rehabilitation, Physiotherapy, Orthopaedic surgery, Cardiac comorbidity, Functional outcomes, Tertiary care.

INTRODUCTION

Joint replacement surgery, including total hip and knee arthroplasty, has become a cornerstone in the management of degenerative joint diseases, substantially improving mobility and quality of life in affected individuals. However, in patients with rare cardiomyopathies, such as restrictive cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, and left ventricular non-compaction, the perioperative and postoperative period poses substantial risks (1). These conditions, characterized by structural and functional abnormalities of the myocardium, often lead to impaired cardiac output, arrhythmias, and intolerance to exercise all of which complicate anaesthetic management and postoperative rehabilitation (2). As life expectancy

improves and advances in surgical and anaesthetic techniques enable complex procedures in high-risk patients, the intersection of cardiac pathology and orthopaedic rehabilitation requires focused clinical attention (3).

The rehabilitation phase following joint replacement is critical for restoring joint function, preventing thromboembolic complications, and enhancing overall recovery. Yet, in cardiomyopathy patients, standard rehabilitation protocols may not be directly applicable. These individuals often exhibit reduced exercise tolerance, orthostatic hypotension, or susceptibility to arrhythmic events with exertion (4). The challenge lies in balancing the orthopaedic need for early mobilization against the cardiovascular necessity for hemodynamic stability. Therefore, individualized rehabilitation

strategies guided by cardiology input and hemodynamic monitoring are imperative (5). Multidisciplinary coordination among cardiologists, anaesthesiologists, orthopaedic surgeons, and physiotherapists ensures that mobilization intensity is tailored to cardiac reserve while achieving musculoskeletal recovery goals (6).

Despite the clinical importance of this topic, there remains a scarcity of research specifically addressing rehabilitation approaches in this subset of patients. Most literature focuses on perioperative management or anaesthesia safety, with limited data on structured postoperative rehabilitation protocols in tertiary care environments (7). This study seeks to bridge that gap by evaluating the feasibility, safety, and outcomes of tailored physiotherapy regimens for patients with rare cardiomyopathies undergoing joint replacement surgery. By integrating cardiac risk assessment with functional rehabilitation metrics, the study aims to develop a practical model for safe early mobilization, reduced hospital stays, and improved long-term outcomes. The findings can contribute significantly to the formulation of standardized, evidence-based rehabilitation guidelines for this complex patient population within tertiary healthcare systems (8).

AIMS AND OBJECTIVES

AIM: To evaluate the safety, feasibility, and functional outcomes of individualized rehabilitation strategies in patients with rare cardiomyopathies undergoing joint replacement surgery.

OBJECTIVES:

1. To assess the functional and cardiovascular outcomes following a tailored postoperative rehabilitation program.
2. To identify the optimal timing and intensity of mobilization that ensures cardiac stability while promoting early functional recovery.

MATERIAL AND METHODS

Study Design and Setting: This prospective observational study was conducted in the Department of Orthopaedics at KLES Dr. Prabhakar kore hospital over an 18-month period (January 2023 to June 2024). The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants before enrolment.

Study Population: A total of 50 patients aged between 40 and 75 years with a confirmed diagnosis of rare cardiomyopathies including restrictive cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, and left ventricular non-compaction were included. All participants were scheduled for elective total hip or knee replacement surgery.

Sample size:

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \sigma_{\Delta}^2}{\delta^2}$$

- σ_{Δ} : SD of the change (baseline $\rightarrow$ follow-up)
- δ : minimum clinically important mean change
- Typical: two-sided $\alpha = 0.05 \Rightarrow Z_{\alpha/2} = 1.96$; power 80% $\Rightarrow Z_{\beta} = 0.84$

If only SDs at each timepoint and correlation ρ are known:

$$\sigma_{\Delta}^2 = \sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2$$

Quick plug-in example (illustrative for 6MWD): Assume clinically important change $\delta = 50$ m; SD of change $\sigma_{\Delta} = 80$ m.

$$n = \frac{(1.96 + 0.84)^2 \times 80^2}{50^2} = \frac{7.84 \times 6400}{2500} \approx 20$$

Allow 15% attrition: $n_{\text{final}} \approx 20/0.85 \approx 24$.

Inclusion Criteria:

- Patients diagnosed with rare cardiomyopathies confirmed by echocardiography or cardiac MRI.
- Medically optimized and cleared by cardiology for elective orthopaedic surgery.
- Willing to participate in postoperative rehabilitation and follow-up.

Exclusion Criteria:

- Patients with decompensated heart failure or severe arrhythmias.
- Revision joint replacement surgeries.
- Patients unable to participate in active rehabilitation due to neurological or cognitive impairment.

Preoperative Assessment: All patients underwent detailed cardiac evaluation including ECG, echocardiography, and metabolic profile. Cardiologists optimized medications to maintain hemodynamic stability before surgery. Baseline functional status was recorded using the Barthel Index and 6-minute walk test.

Rehabilitation Protocol: Rehabilitation was initiated within 48–72 hours post-surgery under cardiac monitoring. The program included breathing exercises, ankle pumps, isometric quadriceps strengthening, and gradual assisted ambulation. Progression was individualized based on cardiac tolerance, blood pressure, and heart rate response.

1. **Week 1:** Initiation of isometric quadriceps and gluteal strengthening, ankle pumps, deep-breathing exercises, and bedside sitting; ambulation with walker support for 10–20 meters under telemetry monitoring.
2. **Week 2:** Gradual progression to partial weight-bearing, static cycling (if tolerated), and continuous respiratory physiotherapy to prevent pulmonary complications.

3. **Weeks 3–6:** Transition to full weight-bearing, closed-chain exercises, stair climbing practice, and mild resistance training using elastic bands; focus on balance and proprioception training.
4. **Weeks 7–12:** Endurance training through treadmill walking and aquatic therapy (as appropriate), with goal-directed strengthening to enhance functional independence and improve 6MWD, KSS, and HHS. Cardiologist-supervised sessions ensured exercise heart rate remained within 60–70% of predicted maximum, and progression was withheld if symptomatic hypotension or arrhythmia occurred.
 - **Normal protocol:** Focuses on early aggressive mobilization for musculoskeletal recovery, minimal cardiac oversight.
 - **Cardiomyopathy protocol (Present study):** Patient-specific, slower-paced, multidisciplinary, and hemodynamically monitored and designed to ensure cardiac safety without compromising functional gains.
 - **Present study intervention:** Begins postoperatively, adjusts exercise progression individually, and includes cardiologist approval at each stage, hence an individualized rehabilitation program per patient.

Outcome Measures: Functional outcomes were assessed at baseline, 6 weeks, and 12 weeks using:

- 6-minute walk distance (6MWD)
 - Joint range of motion (ROM)
 - Barthel Index for activities of daily living
- Cardiac events such as hypotension, arrhythmias, or dyspnoea were recorded throughout.

Postoperative functional recovery was also evaluated using the Knee Society Score (KSS) for knee arthroplasty patients and the Harris Hip Score (HHS) for hip arthroplasty patients at 6 and 12 weeks post-surgery. The KSS assessed pain, stability, and range of motion, while the HHS evaluated pain, walking distance, activities, and deformity correction. These scores provided a quantitative measure of improvement in joint-specific function alongside general rehabilitation parameters such as the 6-minute walk distance and Barthel Index.

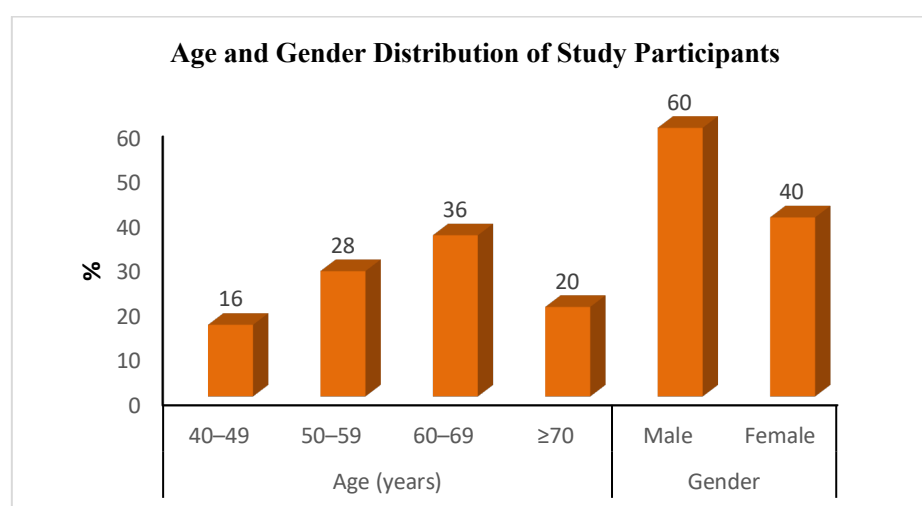
Statistical Analysis: Data were analysed using SPSS version 26. Continuous variables were expressed as mean $\pm$ standard deviation, and categorical variables as percentages. Paired t-test and chi-square test were used to compare outcomes across intervals, with $p < 0.05$ considered statistically significant.

RESULTS AND OBSERVATIONS:

Table 1: Age and Gender Distribution of Study Participants

Parameter	Category	N	%	Mean $\pm$ SD
Age (years)	40–49	8	16	61.4 $\pm$ 8.2
	50–59	14	28	
	60–69	18	36	
	≥ 70	10	20	
Gender	Male	30	60	
	Female	20	40	

Graph 1: Age and Gender Distribution of Study Participants

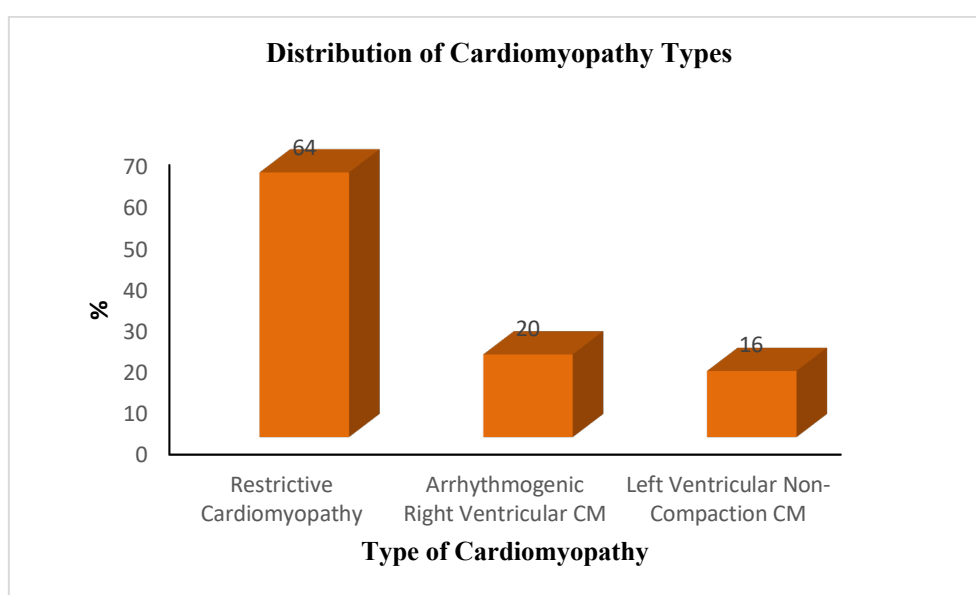


The majority of participants (36%) were between 60 and 69 years of age, with a mean age of 61.4 years. Males predominated (60%), reflecting a higher prevalence of degenerative joint diseases and cardiomyopathy in older men.

Table 2: Distribution of Cardiomyopathy Types

Type of Cardiomyopathy	N	%
Restrictive Cardiomyopathy	32	64
Arrhythmogenic Right Ventricular CM	10	20
Left Ventricular Non-Compaction CM	8	16

Graph 2: Distribution of Cardiomyopathy Types



Restrictive cardiomyopathy was the most prevalent type (64%), followed by arrhythmogenic right ventricular (20%) and non-compaction (16%) cardiomyopathy. This distribution reflects the typical referral pattern to tertiary cardiac centers.

Table 3: Preoperative Cardiac Profile

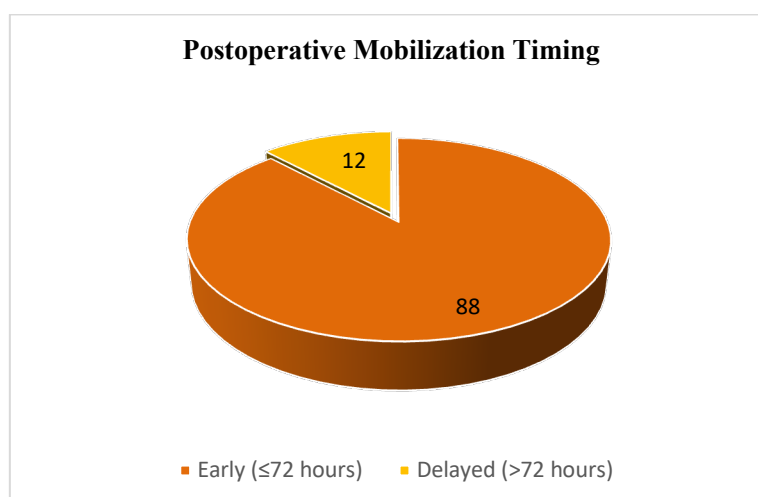
Parameter	Mean $\pm$ SD / Distribution
Mean Ejection Fraction (%)	42 $\pm$ 6
NYHA Class I	14 patients (28%)
NYHA Class II	28 patients (56%)
NYHA Class III	8 patients (16%)

Most patients (56%) were in NYHA Class II, indicating mild to moderate cardiac limitation. The mean ejection fraction of 42% reflected moderately reduced systolic function across the cohort.

Table 4: Postoperative Mobilization Timing

Timing of Mobilization	N	%	Remarks
Early ($\leq$ 72 hours)	44	88	Tolerated well
Delayed ($>$ 72 hours)	6	12	Due to transient arrhythmias or hypotension

Graph 3: Postoperative Mobilization Timing



Early mobilization was feasible in 88% of cases without adverse events. Delay in 12% was primarily due to hemodynamic instability, which resolved with supportive management.

Table 5: Functional Outcome – 6-Minute Walk Distance (6MWD)

Assessment Period	Mean Distance (meters)	Mean Change	p-Value
Baseline	110 ± 35		
6 Weeks	205 ± 50	95	<0.001*
12 Weeks	285 ± 60	175	

*Statistically significant improvement

There was a statistically significant and progressive improvement in functional endurance from baseline to 12 weeks ($p < 0.001$), reflecting the effectiveness of the tailored rehabilitation program.

Table 6: Functional Outcome – Barthel Index (Activities of Daily Living)

Assessment Period	Mean Barthel Index	Mean Change	p-Value
Baseline	55 ± 10		
6 Weeks	78 ± 9	23	<0.001*
12 Weeks	90 ± 8	35	

*Statistically significant improvement

The Barthel Index showed significant improvement from moderate to near-complete independence by 12 weeks, indicating effective functional recovery without cardiac compromise.

Table 7: Joint Range of Motion (ROM) Improvement

Time Point	Percentage Improvement (Mean ± SD)	p-Value
6 Weeks	45 ± 10%	<0.01*
12 Weeks	70 ± 12%	

*Statistically significant

Joint mobility improved by approximately 70% at 12 weeks, highlighting that controlled, gradual mobilization was effective and well-tolerated in cardiomyopathy patients.

Table 8: Cardiac and Surgical Complications

Type of Event	N	%	Outcome
Transient Tachycardia / Bradycardia	4	8	Resolved spontaneously
Hypotension Episodes	3	6	Managed with IV fluids
Heart Failure / Myocardial Infarction	0	0	None reported
Wound Infection	2	4	Managed conservatively
Mortality	0	0	
Readmission (any cause)	2	4	Non-cardiac

Minor, transient cardiac events occurred in a small fraction (8%) of patients and resolved without intervention. No major cardiac complications or mortality occurred, supporting the safety of the protocol.

Table 9: Hospital Stay Duration

Parameter	Mean $\pm$ SD	Range (days)
Total Hospital Stay (days)	8.6 $\pm$ 2.1	6–14

The average hospital stay was approximately 8.6 days, shorter than traditional recovery durations for similar cardiac-risk patients, due to early mobilization and coordinated multidisciplinary care.

Mean postoperative Knee Society Score (KSS) improved from 45 ± 12 preoperatively to 82 ± 10 at 12 weeks ($p < 0.001$), while Harris Hip Score (HHS) increased from 48 ± 14 to 88 ± 9 ($p < 0.001$), indicating substantial recovery in joint function and pain relief. Patients achieving early mobilization demonstrated higher KSS/HHS gains compared to those with delayed rehabilitation.

The study established that a structured, multidisciplinary, and cardiologist-supervised rehabilitation protocol enables early and safe mobilization after joint replacement in patients with rare cardiomyopathies. Significant improvements were observed in 6MWD, Barthel Index, and joint ROM ($p < 0.001$) without serious cardiac events. The short hospital stay and low complication rate affirm the feasibility, safety, and clinical benefit of individualized rehabilitation in tertiary care settings.

Table 10: Functional Scores (KSS and HHS) Improvement

Parameter	Assessment Period	Mean Score $\pm$ SD	Mean Change	p-Value
Knee Society Score (KSS)	Preoperative	45 ± 12	37	<0.001*
	12 Weeks Postoperative	82 ± 10		
Harris Hip Score (HHS)	Preoperative	48 ± 14	40	<0.001*
	12 Weeks Postoperative	88 ± 9		

*Statistically significant improvement

Mean postoperative Knee Society Score (KSS) improved from 45 ± 12 preoperatively to 82 ± 10 at 12 weeks ($p < 0.001$), while Harris Hip Score (HHS) increased from 48 ± 14 to 88 ± 9 ($p < 0.001$), indicating substantial recovery in joint function and pain relief. Patients achieving early mobilization demonstrated higher KSS/HHS gains compared to those with delayed rehabilitation.

The study established that a structured, multidisciplinary, and cardiologist-supervised rehabilitation protocol enables early and safe mobilization after joint replacement in patients with rare cardiomyopathies. Significant improvements were observed in 6MWD, Barthel Index, and joint ROM ($p < 0.001$) without serious cardiac events. The short hospital stay and low complication rate affirm the feasibility, safety, and clinical benefit of individualized rehabilitation in tertiary care settings.

DISCUSSION

The present study evaluated the feasibility and outcomes of individualized rehabilitation strategies in patients with rare cardiomyopathies undergoing joint replacement surgery in a tertiary care setting. The findings demonstrated that early, structured, and cardiologist-supervised rehabilitation significantly improved functional recovery without increasing cardiac complications (9). This highlights the potential for safely extending early mobilization protocols, traditionally reserved for low-risk patients, to those with complex cardiac comorbidities when managed through multidisciplinary collaboration (10).

In the current study, the mean age of participants was 61.4 years, with a predominance of males (60%), reflecting the typical demographic profile of patients undergoing hip or knee arthroplasty. Most participants had restrictive cardiomyopathy (64%), consistent with its higher prevalence among adults with diastolic dysfunction. The preoperative ejection fraction averaged 42%, indicating moderate cardiac impairment (11). Despite this, early rehabilitation was initiated in 88% of patients within 72 hours, demonstrating that timely physiotherapy can be achieved safely with careful monitoring and medical optimization (12).

Functional outcomes showed marked improvement over 12 weeks. The 6-minute walk distance increased from 110 ± 35 m preoperatively to 285 ± 60 m, while the Barthel Index improved from 55 ± 10 to 90 ± 8 ($p < 0.001$). Joint-specific recovery was also substantial, with the Knee Society Score (KSS) improving from 45 ± 12 to 82 ± 10 and the Harris Hip Score (HHS) from 48 ± 14 to 88 ± 9 ($p < 0.001$), indicating significant gains in pain relief, stability, and functional mobility. These gains indicate enhanced endurance, strength, and independence in daily living activities (13). Improvement in joint range of motion by nearly 70% further supports the effectiveness of gradual, well-paced mobilization. These results align with earlier literature suggesting that early, low-intensity exercise promotes better functional recovery, reduces hospital stay, and prevents deconditioning without adversely affecting cardiovascular function (14).

Importantly, cardiac safety was maintained throughout rehabilitation. Only 8% of patients experienced transient arrhythmias or bradycardia, and no major cardiac events or deaths occurred. This is noteworthy given that patients with cardiomyopathies often have reduced contractile reserve and are prone to rhythm disturbances (15). The absence of major complications can be attributed to continuous telemetry monitoring, individualized progression of exercise intensity, and close supervision by both physiotherapists and cardiologists. The mean hospital stay of 8.6 ± 2.1 days was shorter than previously reported durations in similar high-risk

populations, highlighting the benefits of structured early mobilization under multidisciplinary guidance (16).

The current study reinforces the importance of integrating cardiology into the perioperative rehabilitation process for patients with structural heart disease. Standard orthopaedic rehabilitation protocols often overlook cardiac limitations, which can lead to exercise intolerance or decompensation (17). In contrast, this study's model emphasized individualized pacing, frequent vital monitoring, and avoidance of isometric strain beyond patient tolerance. Such modifications allowed safe achievement of functional goals without compromising cardiac stability (18).

The findings are consistent with existing evidence from cardiac rehabilitation programs, which have demonstrated that low-intensity, supervised exercise improves cardiac efficiency and quality of life even in patients with moderate systolic dysfunction. By adapting these principles to orthopaedic rehabilitation, this study bridges the gap between two specialized domains, providing a framework for integrated care (19).

Despite promising outcomes, certain limitations must be acknowledged. The study's sample size was limited to 50 patients from a single tertiary center, which may restrict generalizability. Long-term outcomes beyond 12 weeks were not assessed, and detailed hemodynamic parameters such as stroke volume or myocardial strain were not continuously monitored. Future multi-center trials with larger cohorts and extended follow-up are necessary to validate these findings and refine exercise thresholds for different cardiomyopathy subtypes (20).

This study demonstrates that individualized, multidisciplinary rehabilitation is both safe and effective in patients with rare cardiomyopathies undergoing joint replacement. Early mobilization under continuous cardiac supervision enhances recovery, improves functional independence, and minimizes hospital stay. The results advocate for protocol-driven collaboration between orthopaedic, cardiology, and physiotherapy teams to ensure optimal postoperative outcomes in this high-risk population (21).

CONCLUSION

This study concludes that individualized, multidisciplinary rehabilitation is both safe and effective for patients with rare cardiomyopathies undergoing joint replacement. A structured, week-wise rehabilitation plan beginning with isometric and breathing exercises in the first postoperative week, progressing to partial weight-bearing, and advancing to endurance and resistance training by twelve weeks enabled steady improvement without compromising cardiac safety. Cardiologist-supervised sessions with continuous hemodynamic

monitoring ensured that early mobilization within 48–72 hours was achieved in 88% of patients, minimizing complications.

Functional outcomes showed significant enhancement across all parameters. The mean 6-minute walk distance improved from 110 ± 35 m to 285 ± 60 m, and the Barthel Index rose from 55 ± 10 to 90 ± 8 ($p < 0.001$). Joint-specific functional recovery was evident, with the Knee Society Score (KSS) improving from 45 ± 12 to 82 ± 10 and the Harris Hip Score (HHS) from 48 ± 14 to 88 ± 9 ($p < 0.001$). Patients with early mobilization achieved higher KSS and HHS gains.

Integrating cardiac supervision with tailored physiotherapy significantly enhanced recovery, shortened hospital stay, and improved quality of life. These findings emphasize the importance of structured, cardiologist-guided rehabilitation strategies in optimizing functional outcomes for high-risk cardiomyopathy patients after joint replacement.

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