ORIGINAL ARTICLE

Effects of Centre Based vs. Telerehabilitation using an Interval and Continuous Aerobic Training among Post-Coronary Revascularization Patients-A Randomized Controlled Trial

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Abstract

Background: This study aimed to investigate the most effective rehabilitation techniques for empowering cardiac patients on their journey to recovery and well-being in cardiac care, thus comparing the difference between continuous aerobic and high-intensity interval training between centre-based settings and via telerehabilitation.

Methodology: This randomized controlled trial included 80 patients who had undergone coronary revascularization procedures, were enrolled in the cardiac rehabilitation department, and met the criteria for Phase II. Patients were assigned to Group A (n=20), which performed continuous moderate-intensity aerobic exercises for 3-4 days/week at 50%-70% MHR, while Group B (n=20) received high-intensity interval training with four successive intervals over 3-4 days. Telerehabilitation was performed by Group C (n=20) following the same protocol as Group A, while Group D (n=20) followed Group B.

Results: The within-group analysis revealed significant improvements across all groups on the 6-Minute Walk Test (6MWT) and the Self-reported Seven-Day Physical Activity Questionnaire (PAR) ($p<0.001$). Significant improvements were observed in the Rate of Perceived Exertion (RPE) ($p<0.05$) in Groups A and B. In contrast, centre-based rehabilitation showed substantial gains on 6MWT and RPE scores ($p<0.05$) compared to telerehabilitation on ANOVA.

Conclusion: Centre-based rehabilitation outperformed telerehabilitation in patients undergoing Phase-III cardiac rehabilitation. However, high-intensity interval-based training was more effective in centre-based settings while continuous-moderate-intensity aerobic exercises were well-performed in telerehabilitation.

Keywords
Aerobic Exercises, Cardiac Rehabilitation, Coronary Artery, Physical Activity.

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Introduction

Cardiovascular disease (CVD), a global health concern, is a leading cause of death and morbidity among non-communicable diseases. According to Global Burden of Disease (GBD), CVD cases have been soaring since 1990, making the condition more lethal worldwide[1]. However, more than 17.9 million deaths in 2016 were reported by the World Health Organization (WHO), which highlighted the severity of this condition, which accounts for 31% of global mortality. Among all types of CVD, coronary artery disease (CAD) is the most frequent cardiac condition, which has a devastating impact on the quality of life[2].Many revascularization procedures, such as coronary artery bypass graft (CABG) and percutaneous coronary intervention (PCI), are the protocols of preference.. Though these are the most preferred surgical methods, they are also reported to cause significant physiological and psychological problems, including deterioration in physical fitness and health-related quality of life (HRQoL)[3-4].

CABG has been previously shown to be a promising intervention in improving a patient's physical and mental health in the 5-year postoperative period. However, most recent studies showed altered conclusions showing reductions in HRQoL after revascularization, showing a visible difference between the pre and post-operatively, like resting heart rate, rate of perceived exertion scale and quality of life[5]. Due to these results, medical professionals are now paying attention to the need for cardiac rehabilitation (CR) as a crucial component of patient improvement. These concerns include enhancing decreased aerobic capacity, decreased levels of physical exercise, and general quality of life[6]. CR has embarked on its position as an independent field to foster patients' recovery and general well-being after a cardiac event[7]. CR lets people gain control over their lives in order to return to their daily activities. It focuses on the physical and emotional challenges of recovery to educational activities that clarify the complexities of cardiac illness[8]. Exercise, a fundamental component of CR, can be provided in centre or home-based settings and can take many forms, including strength training and aerobic exercise[9]. A smooth transition from the acute phase experienced within a hospital to the home or community environment occurs as the continuum of care develops. Importantly, CR plays a crucial part in preparing patients for and following cardiac surgery, with the overriding goal of optimizing functional status and aerobic capacity[10]. In this complex web of treatment, Phase-II CR stands out as a crucial turning point. It is focused on assessing and improving a patient's ability to exercise in the six weeks that follow the initial in-hospital phase.

A decade after CABG procedures, studies show a reduction in all-cause mortality of over 12%, demonstrating the extraordinary benefits of engaging in CR programs[11]. These optimistic statistics have not, however, always been reflected in the patient results in rehabilitation facilities, mainly after myocardial infarctions (MI), CABG operations, and percutaneous coronary interventions (PCI)[12]. However, the CR landscape has changed throughout time, reflecting the dynamism of medical advancement. The foundation of CR has historically been a centre-based rehabilitation program, but the unrelenting march of time has ushered in innovations meant to democratize access to this essential resource[13]. Patients who might have difficulties attending conventional centre-based sessions can now benefit from home-based programs and the development of e-health initiatives, sometimes called 'telerehabilitation'. Despite significant documentation of the effects of CR on functional ability, levels of physical activity, and quality of life, Phase-III CR has received the majority of attention. In light of this, this study sets out to conduct a critical investigation to illuminate the future of patients who have had post-coronary revascularization. The main focus of the investigation centres on a crucial comparison: the differences between centre-based and telerehabilitation, using intermittent and continuous aerobic training methods.

Methodology

Study Design and Setting

This study was a single-blinded, randomized controlled trial conducted at the Cardiac Rehabilitation Department of Memon Medical Hospital, Karachi.

Participants Eligibility and Recruitment

A total of 80 patients who had undergone coronary revascularization procedures and were enrolled in the cardiac rehabilitation department were eligible for Phase-III CR. Amongst which patients aged 25 years or older, have undergone percutaneous coronary intervention or coronary artery bypass grafting, have a functional categorization of Class I or II, have ejection fraction >35%, and can understand how to accept, receive, and send text messages on mobile devices were included. Patients who had unstable angina, uncontrolled hypertension, severe aortic stenosis, uncontrolled atrial or ventricular arrhythmias, and severe cognitive impairment were excluded. Additionally, patients with several coexisting ailments were disqualified, including those with diabetes, cancer, infectious diseases, dementia, mental illnesses, eating disorders, anxiety disorders, or drug misuse.

Intervention Protocol

Eighty patients were equally divided into four different exercise programs with n=20 in each group via a simple random sampling technique. Eligible patients could accept or refuse participation in the trial during their initial clinic appointment after receiving thorough information about the study. An informed consent form was completed, dated, and sent back to the researcher by those who chose to participate. Participants were randomly allocated to the continuous or interval-based training exercise group after voluntarily choosing an envelope for

randomization. The maximal heart rate of each participant was determined to create a baseline and guard against any possible problems. Participants then received an eight-week fitness training program that was prescribed to them, carried out under supervision either in a centre-based rehabilitation centre or by remote monitoring. The following treatment protocols were used:

1. ***Group-A (Continuous Moderate-Intensity Aerobic Exercise)***
   - Centre-based
   - 3–4 days a week, on average
   - 45 to 60 minutes
   - 5 to 10 minutes of warm-up
   - 30 minutes of moderate aerobic activity, such as walking or using a treadmill
   - 50% and 70% of maximal heart rate measured using Karvonen formula
   - 5 to 10 minutes for cooling down

2. ***Group-B (High-Intensity Interval Based Training)***
   - Centre-based
   - 3–4 days a week, on average
   - 45 to 60 minutes
   - 5 to 10 minutes of warm-up
   - First interval: a 4-minute, intense period to get the heart rate into the target range
   - Four subsequent intervals, then a 2-minute rest break
   - 3-5 minutes for cool down
   - 70–75% of peak HR for intensity

Telerehabilitation was conducted with Group C following the same protocol as Group A and Group D following the same protocol as Group B. Participants in the centre-based group completed a monitored training regimen under the direction of professional physical therapists. On the other hand, the telerehabilitation group was given wearable equipment to make it easier to track exercises and let them work out in the comfort of their homes or local parks. A smooth transition to the centre-based training program was facilitated in cases where participants expressed their inability to engage in telerehabilitation. This transition ensured their active participation and strict adherence to the study protocol. Weekly mobile contact was also used to continue data collection and communication with distant training participants.

Outcome Measures

All participants were assessed on these outcome measures at baseline and at the end of 6-week intervention:

- ***Six-Minute Walk Test (6MWT)***
  This test was used to assess stamina and functional abilities of participants[14].

- ***Borg Rate of Perceived Effort Scale***
  The Borg scale is a self-reported subjective impression of dyspnea[15].

- ***Stanford Seven-Day Physical Activity Recall Questionnaire (PAR)***
  Physical activity has been assessed using the Stanford PAR questionnaire to determine the participants' normal physical activity behaviors[16].

Ethical Considerations

The Institutional Review Board (IRB) has examined and approved the study under protocol number MMH/2022/04/56. All participants provided informed permission, emphasizing their voluntary involvement and the freedom to leave at any time without penalty. Data anonymization procedures were used, and participants' data were subject to strict privacy and confidentiality protections. The study was conducted by ethical standards, focusing on the protection and welfare of participants at all times.

Results

The findings revealed that the mean age of the participants included in the study was 58.35±1.35 years, with more males (n=47) than females (n=33). The descriptive analysis further showed that the average age of male participants was 59.1±1.12 years and females were 58.11±1.14years. Detailed demographic descriptions are provided in Table-1:

Table-1 Demographic Description of Study Participants in Groups

Groups		Number of Males 'n'	Number of Females 'n'	Age of male participants (Mean±SD)	Age of female participants (Mean±SD)
Centre-based	Group-A	14	6	59.33±1.15	58.45±1.12
	Group-C	10	10	58.75±2.25	57.89±1.35
Telerehabilitation	Group-B	13	7	58.91±1.05	57.91±1.13
	Group-D	10	10	59.41±1.02	58.21±1.34

Within-group analysis was conducted using a paired t-test at 95% confidence interval revealed a significant difference in the mean favoring positive responses of intervention strategies on the given outcome measures ($p<0.05$). The analysis showed that in the six-minute walk test, the participants in all groups had shown significant improvement with a mean difference (MD) of (72.2±1.3, p=0.02) in Group-A, (MD=44.6±0.97, p=0.03) in Group-C, (MD=73.79±2.4, p=0.019) in Group-B and (MD=52.13±3.2, p=0.0240 and Group-D. The effects of the intervention on the rate of perceived exertion scale were also significant ($p<0.05$) in all groups with an MD of (2.9±1.01, p=0.03) in Group-A, (MD=1.8±1.3, p=0.89) in Group-C, (MD=3.01±0.89, p=0.03) in Group-B and (MD=1.69±1.21, p=0.78) in Group-D. Further, on the self-reported seven-day physical activity

questionnaire (PAR), the effects of intervention strategies was also significant (p<0.001). The details are depicted in Table-2.

Table-2 Within-group Analysis of Effects of Interventional Strategies on Outcome Measures

Variables	Baseline Mean±SD	After 6-weeks Mean±SD	Mean Difference Mean±SD	t-value	p-value
6MWT (Distance measured in meters)					
Group-A	458.25±1.53	530.45±1.24	72.2±1.3	5.56	0.02
Group-C	475.75±2.09	520.35±1.5	44.6±0.97	3.29	0.03
Group-B	460.83±3.2	534.62±2.1	73.79±2.4	5.59	0.019
Group-D	463.11±2.01	515.24±1.19	52.13±3.2	4.48	0.024
Modified Borg Rate of Perceived Exertion Scale (RPE)					
Group-A	8.1±1.2	5.2±1.1	2.9±1.01	3.02	0.03
Group-C	7.5±1.3	5.7±1.04	1.8±1.3	0.89	0.04
Group-B	8.02±0.98	5.01±1.05	3.01±0.89	3.1	0.03
Group-D	7.29±1.01	5.6±1.1	1.69±1.21	0.78	0.04
Stanford Seven-Day Physical Activity Recall Questionnaire (PAR) (Duration of exercises performed in minutes/week)					
Group-A	53.2±1.25	125.25±5.58	72.05±3.89	5.12	<0.001
Group-C	56.24±2.13	85.14±4.17	28.9±2.41	3.98	<0.001
Group-B	52.15±3.25	127.34±2.24	75.19±4.12	5.92	<0.001
Group-D	58.98±2.47	86.45±1.25	27.47±3.02	3.8	<0.001

Moreover, ANOVA was applied to determine the difference between the groups. The findings revealed that centre-based group intervention was significantly better (p<0.05) than the telerehabilitation group in improving the six-minute walk test; however, no difference between the group was found in continuous moderate-intensity aerobic exercise and high-intensity interval-based training (p>0.05) Similarly, on RPE and PAR also, the effects of the centre-based training group were significantly better (p<0.05) than those of the telerehabilitation group; however, on RPE, the effects of the high-intensity interval-based training were significantly (p<0.05) better than those of the continuous moderate-intensity aerobic exercise in centre training. In contrast, the effect of continuous moderate-intensity aerobic exercise on telerehabilitation group was significantly better (p<0.05) than the high-intensity interval-based training group. Likewise results, observed in PAR (Table-3).

Table-3 Between-group Analysis of Effects of Interventional Strategies on Outcome Measures				
Variables	Factors	Value	After 6-weeks Mean±SD	P-value
6MWT (Distance measured in meters)				
Group-A	C	530.45±1.24	520.35±1.5	<0.05
	B		534.62±2.1	0.063
	D		515.24±1.19	<0.05
Group-C	A	520.35±1.5	530.45±1.24	<0.05
	B		534.62±2.1	<0.05
	D		515.24±1.19	0.056
Group-B	A	534.62±2.1	530.45±1.24	0.063
	C		520.35±1.5	<0.05
	B		515.24±1.19	<0.05
Group-D	A	515.24±1.19	530.45±1.24	<0.05
	C		520.35±1.5	0.056
	B		534.62±2.1	<0.05
Modified Borg Rate of Perceived Exertion Scale (RPE)				
Group-A	C	5.2±1.1	5.7±1.04	<0.05
	B		5.01±1.05	<0.05
	D		5.6±1.1	<0.05
Group-C	A	5.7±1.04	5.2±1.1	<0.05
	B		5.01±1.05	<0.05
	D		5.6±1.1	>0.05
Group-B	A	5.01±1.05	5.2±1.1	<0.05
	C		5.7±1.04	<0.05
	B		5.6±1.1	<0.05
Group-D	A	5.6±1.1	5.2±1.1	<0.05
	C		5.7±1.04	>0.05

	B		5.01±1.05	<0.05
Stanford Seven-Day Physical Activity Recall Questionnaire (PAR) (Duration of exercises performed in minutes/week)				
Group-A	C	125.25±5.58	85.14±4.17	<0.05
	B		127.34±2.24	<0.05
	D		86.45±1.25	<0.05
Group-C	A	85.14±4.17	125.25±5.58	<0.05
	B		127.34±2.24	<0.05
	D		86.45±1.25	<0.05
Group-B	A	127.34±2.24	125.25±5.58	<0.05
	C		85.14±4.17	<0.05
	B		86.45±1.25	<0.05
Group-D	A	86.45±1.25	125.25±5.58	<0.05
	C		85.14±4.17	<0.05
	B		127.34±2.24	<0.05

Discussion

The analysis of the study has provided important new information on the effects of various intervention modalities on post-coronary revascularization patients undergoing Phase-III CR. With a broad cohort of participants and an average age of 58.35±1.35 years, the study included more male participants (n=47) than female ones (n=33). All four groups responded significantly favorably to the intervention techniques, according to within-group analyses utilizing paired t-tests with a 95% Confidence Interval ($p<0.05$). Participants in all groups had substantial gains in the 6MWT, with MD of 72.2±1.3 (Group-A), 44.6±0.97 (Group-C), 73.79±2.4 (Group-B), and 52.13±3.2 (Group-D). Likewise, all groups showed significant ($p<0.05$) effects of the intervention on the rate of perceived exertion (RPE) scale, with MD values of 2.9±1.01 (Group-A), 1.8±1.3 (Group-C), 3.01±0.89 (Group-B), and 1.69±1.21 (Group-D). International techniques showed statistically significant impacts ($p<0.001$) on the self-reported seven-day PAR questionnaire. Group difference analysis showed that centre-based group therapies were superior to telerehabilitaion groups ($p<0.05$) in enhancing the 6-minute walk test however PAR showed no significant difference in each group. Thus, the conclusions emphasize the effectiveness of exercise to regain the acquired level of physical activity. This finding also provides a practical and cost-effective substitute, highlighting the benefits of centre-based treatments, notably boosting walking ability.

In systematic reviews and meta-analyses, the importance of telerehabilitation to see the difference in CR showing the same results. The lowering of cardiovascular risk factors and psychological well-being, as shown by anxiety and depression scores, did not show any appreciable changes, however. Notably, cardiac telerehabilitation had a high completion rate, with few adverse events recorded during follow-up, and had a favorable effect on long-term quality of life[17]. The findings point to the potential of patient-centred, monitoring-enabled telerehabilitation programs to improve cardiopulmonary fitness, quality of life, and long-term outcomes for CAD patients, heralding a promising paradigm shift in CR[17]. A study compared cardiorespiratory outcomes of a 3-week telerehabilitation program to traditional centre-based CR in response to the COVID-19 pandemic. Patients were split into two groups, participating in 4 weekly fitness training sessions. The telerehabilitation group self-assessed their degree of exertion while using linked watches to track heart rate. The outcomes demonstrated significant gains in cardiorespiratory fitness in both groups, as seen by increases in peak oxygen uptake (VO2peak), oxygen uptake at the first ventilatory threshold (VO2 at VT1), and peak workload[18]. Notably, there were no significant differences between the conventional CR and telerehabilitation groups, indicating that both methods are equally successful at increasing patients' fitness.

The study underlines the potential of telerehabilitation as a secure and practical option for patients. It may play a significant role in the future in terms of providing treatment for those unable to receive centre-based CR[18]. The effect of home-based cardiac telerehabilitation (HBCTR) on subjects who underwent PCI was also examined in one systematic review and meta-analysis[19]. Outcome measures, including 6MWT and QoL, were used to measure the primary outcomes in all five studies conducted between 2013 and 2022. According to this review, the HBCTR intervention group performed statistically better on the 6MWT than the control group. However, no noticeable difference was noted in QoL. HBCTR also showed alterations in lipid profiles, including triglycerides and low-density lipoprotein cholesterol, and a substantial decrement in systolic blood pressure. Thus, HBCTR is a successful form of CR for improving aerobic fitness[19].

The strength of this study includes the diversification and wide age range. The following study can be applied to a larger sample of patients. Analysis based on gender specification can also be made by including both male and female participants, which also helps lessen gender bias. Additionally, the controlled comparisons between intervention groups will help design the internal validity. Thus, the conclusions provide a comprehensive, detailed efficiency of various exercise training programs in raising post-coronary revascularization patients' physical activity levels, perceived effort, and functional capacity. The limitation of our study includes a short time of 6 weeks, which may affect the restriction on long-term effects.

Conclusion

The study findings revealed improved Phase-III of CR using the centre-based therapy. These results provided the beneficial effects of improving functional ability, perceived effort, and physical activity levels. Telerehabilitation can be disregarded as it has been shown to provide

some valuable effects. However, the study emphasizes the superiority of centre-based therapy, especially regarding enhancing walking capacity.

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Conflict of Interest
None.

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None.

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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

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Acquisition, Analysis or Interpretation of Data: Zehra F, Khan MU, Junejo S, Khan A

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All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.