LITERATURE REVIEW

Cardiac Rehabilitation in Post Covid-19 Patients with Cardiovascular Diseases Complications: Review Article

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ABSTRACT

The novel coronavirus disease 2019 (COVID-19) targets the respiratory system. However, reports have associated this illness with several serious cardiovascular consequences in post-COVID-19 patients. This review aimed to summarize the prevalence and types of cardiovascular complications among COVID-19 survivors as well as the role of cardiac rehabilitation in combating post-COVID-19 patients.

A stepwise literature search of PubMed and Google Scholar identified 18 articles that met the inclusion criteria. Some of the common sequelae, including cardiovascular morbidity mentioned in post COVID-19 patients are Myocarditis, Arrhythmia, Heart Failure (HF), Acute Coronary Syndrome (ACS), and Venous Thromboembolism (VTE). Several studies have consistently reported myocarditis and arrhythmias, indicating that SARS-CoV-2 directly affects the cardiac electrophysiology. HF is another prevalent complication that requires a multifaceted approach for patient care. The incidence of VTE, including deep vein thrombosis and pulmonary embolism, has markedly increased because of the hypercoagulable state induced by the virus. ACS, such as myocardial infarction, has also been reported to have an infection-induced inflammatory response that is thought to hasten atherosclerotic plaque rupture and thrombosis. Cardiac Rehabilitation (CR), a personalized outpatient exercise and education program, is crucial for managing these complications and for improving the overall health and quality of life of patients. The benefits of CR in post-COVID-19 patients include restoring cardiopulmonary endurance, preventing the deterioration of their condition, and reducing future cardiac issues. Given the high prevalence and variety of cardiovascular complications in COVID-19 survivors, comprehensive cardiac monitoring and rehabilitation are essential to reduce the long-term adverse outcomes.

Keywords: SARS-COV-2, post-covid-19, cardiac rehabilitation, survivors, coronary disease

ABSTRAK

Penyakit novel coronavirus 2019 (COVID-19) menargetkan sistem pernapasan. Namun, banyak penelitian telah mengaitkan penyakit ini dengan berbagai konsekuensi kardiovaskular yang besar dan serius di antara pasien pasca-COVID-19. Tinjauan ini dimaksudkan untuk merangkum prevalensi dan jenis komplikasi kardiovaskular di antara para penyintas COVID-19, serta peran rehabilitasi jantung dalam mengelola para pasien pasca-COVID-19. Pencarian literatur dilakukan bertahap di PubMed dan Google Scholar sehingga diperoleh 18 artikel yang memenuhi kriteria inklusi. Beberapa kriteria umum, termasuk morbiditas kardiovaskular yang disebutkan pada pasien pasca COVID-19 adalah miokarditis, aritmia, gagal jantung (HF), sindrom koroner akut (ACS), dan tromboemboli vena (VTE). Beberapa studi konsisten melaporkan miokarditis dan aritmia, menunjukkan bahwa SARS-CoV-2 memang berdampak langsung pada elektrofisiologi jantung. HF adalah komplikasi prevalen lain yang memerlukan pendekatan beragam terhadap perawatan pasien. Insiden VTE, termasuk trombosis vena dalam dan emboli paru, telah meningkat secara signifikan karena keadaan hiperkoagulopati yang diinduksi oleh virus. ACS, seperti infark miokard, juga telah dilaporkan, sebagai respons inflamasi yang disebabkan oleh infeksi, dianggap mempercepat proses rupturnya plak aterosklerosis dan trombosis. Cardiac Rehabilitation (CR), program latihan dan edukasi rawat jalan yang dipersonalisasi, sangat penting untuk mengelola komplikasi ini dan meningkatkan kesehatan serta kualitas hidup pasien secara keseluruhan. Manfaat CR pada pasien pasca-COVID-19 termasuk mengembalikan daya tahan kardiopulmoner, mencegah penurunan kondisi mereka, dan mengurangi masalah pada jantung di masa depan. Mengingat prevalensi dan variasi komplikasi kardiovaskular yang tinggi pada penyintas COVID-19, pemantauan dan rehabilitasi jantung yang komprehensif penting untuk mengurangi hasil buruk jangka panjang.

Kata kunci: : SARS-COV-2, post-covid-19, rehabilitasi jantung, penyintas, penyakit jantung

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INTRODUCTION

COVID-19 is an acronym for corona (Co), virus (Vi), and disease (D), with the number 19 referring to the year 2019 when the first case was identified in December.[1] While primarily a respiratory illness characterized by symptoms such as a dry cough and shortness of breath, there is mounting evidence linking COVID-19 to significant cardiovascular issues.[2,3] Myocarditis and arrhythmias are among the most frequent heart-related complications observed in those infected with the virus. Studies indicate that the occurrence of heart

failure (HF) and myocarditis, as complications of COVID-19, was approximately five and seven times higher, respectively, particularly among those who did not survive the illness.[4] This trend holds true irrespective of pre-existing cardiovascular conditions. Additionally, thromboembolic disorders have been identified as frequent aftereffects in patients recovering from COVID-19.[5]

The severity was also seen in the risk factors of cardiovascular disease (CVD) in COVID-19 complications, including old age and comorbidities, such as CVD, lung, renal, and diabetes.[2-4] The other risk factors are systemic inflammation, coagulation abnormalities, severe illness, multi-organ dysfunction, and immobility.[4] It was explained that the patient needs rehabilitation.

Rehabilitation in CVD is also called Cardiac Rehabilitation (CR), a customized outpatient exercise and education program.[6] The activity is adapted to each patient's ability, depending on the heart disease's problem and severity.[7] The objectives of CR are to develop a strategy aimed at assisting patients in restoring their cardiopulmonary stamina, preventing deterioration of their condition, lowering the likelihood of future cardiac issues, and enhancing their overall health and quality of life.[8,9] CR is deemed necessary according to the situation and necessity.[10] During the ongoing COVID-19 pandemic, where individuals are advised to stay at home to minimize virus transmission, the use of CR becomes increasingly important. However, limited literature is available regarding CR. Consequently, this study aimed to address the benefits of CR in COVID-19 patients.

METHODS

At the start of April 2024, articles from the past four years were gathered from databases via PubMed and Google Scholar, without restrictions on publication type. The search utilized keywords such as "Post Acute COVID-19 Syndrome" OR "Long Haul COVID-19" OR "Post COVID-19 Condition" AND "cardiovascular diseases" OR "Cardiac Events" OR "Adverse Cardiac Events" AND "Cardiac Rehabilitation." OR "Cardiovascular Rehabilitations" Only articles that precisely matched the keywords of the research topic were written in English and were available in the full text were selected for inclusion.

RESULTS

This review describes CVD complications in COVID-19 patients with and COVID-19 survivors, commonly referred to as post-COVID-19 patients, and the need for CR. [5, 11,12] We found 42 articles' titles and abstracts and 18 articles were related to the topic (Table 1).

Table 1. The literature review results of CVD complications in COVID-19 and COVID-19 survivors, commonly called post-COVID-19 patients, and the need for CR [13-30]

Author	CVD Complications in Post COVID-19 Patients	CR for Post COVID-19 Patients with CVD Complications
Nicholls, S. J., et al.[13]	Myocarditis, MI, arrhythmia, and VTE	The integration of TR in rural, remote and regional area respond to the specific needs identified: A means to close the gap with respect to equitable access for consumers residing in these locations for more accessible and less costly healthcare. Unparallel benefits are rendered as when using this technology, such as ease of use for healthcare providers and patients, cost savings on trips related to travel time, improved patient independence and self-management, better access to healthcare facilities or autonomy in taking the treatment around their locations, better management or compliance with drug schedules and communication between healthcare providers leading to integrated care.
Besnier, F., et al.[14]	Myocarditis, VTE, arrhythmias, and HF	Comprehensive therapeutic education is offered to all the CR programs including nutritional aspects, lifestyle, stress management and tailored exercise training programs as well as cardiovascular risk factor management and medication optimization for returning to work. Cognitive training programs have also been considered a component in the treatment plans. The effectiveness of our programs is evidenced by science and proven. The study demonstrates that taking part in a CR programmed cuts the risk not only from total but also cardiovascular mortality by 25–30%. It lowers rehospitalization within 12 months post-rehabilitation up to 30%, versus patients who obtain standard care without CR programs. Moreover, the programs are cost-efficient, safe and more effective in continuing one an active lifestyle for the medium term as supported by TR. Both programs are similarly effective to the other modalities in improve VO2 max.
Mureddu, G. F., et al.[15]	HF and VTE	All procedures should be accompanied by patient education. In addition, most patients need to regularly conduct the exercise training in their inpatient rooms assisted by such equipment as exercise bikes and pedal exercisers. In addition to that, the patients need to be informed with effective ways of protection against any viruses such as how to wash hands properly, using a mask for covering face and mouth, wearing gloves for touching things hand sanitizer. Some visual illustrations can be an effective way to guide these practices. Over-body and fatigue muscle weakness need to be among followed by a compromised immune system, the most frequent symptoms individuals have reported having. These are only warm-up exercises, however. We have much prior physical reconditioning to do. Before the reconditioning program could start, we would need to gather indicators like BP, SpO2, HR, RR, and telemetric monitoring.

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Swarnakar R., et al.[16]	Acute cardiac damage is observed in 8–12% of cases, heart failure (HF) in 23–52%, arrhythmias range from 8.9–16.7%, and cases of acute myocarditis are also noted.	Currently, the focus of COVID-19 rehabilitation is on providing care during hospital or ICU stays.
Muhammad K O., et al[17]	Multiple cardiovascular sequelae including direct MI, arrhythmias, and cardiomyopathies, persistent cardiac ischemia in patients with no previous history of coronary disease, atrial and ventricular arrhythmias, and the development of new-onset HF	COVID-Rehab is an 8-week, center-based, outpatient cardiopulmonary rehabilitation program that will test the efficacy of persons with an impaired cardiorespiratory fitness related to the long form of COVID-19 in increasing cardiorespiratory fitness (VO2max). Research has generally maintained that patients with or without previous cardiovascular disease are at risk of developing myocardial injury resulting from long COVID. Research should continue to define the risks for cardiovascular mortality and the effectiveness of CR in the post-acute and chronic phases of COVID-19.
Terzic CM, et al[18]	MI, ACS, myocarditis, cardiomyopathy, arrhythmias, HF, and DVT.	PASC should be enrolled in a center-based, home-based, or hybrid cardiopulmonary rehabilitation program, including aerobic and resistance exercise.
Chilazi M, et al[19]	Myocarditis, stress cardiomyopathy, MI, and arrhythmia	Critically ill COVID-19 patients should receive a 4- to 6-week follow-up for assessment related to the requirement of further investigations integrated with multidisciplinary rehabilitation.

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Author	CVD Complications in Post COVID-19 Patients	CR for Post COVID-19 Patients with CVD Complications
Quinn K L et al[20]	Inappropriate sinus tachycardia, POTS	Developing such a framework, the Post COVID-19 Rehabilitation Response Framework, which is based on three core pillars—standardized screening of certain symptoms and functional impairments; creating integrated care pathways to identify and guide a person's rehabilitation journey; and offering self-management and educational support for those with long COVID and their healthcare workers. They advise ceasing unsupervised exercise and that a symptom-led, subthreshold structured activity program be supported whereby the level of activity is maintained below the threshold that triggers the beginning of symptom flare. Furthermore, energy conservation strategies like pacing within the envelopes should be integrated and when and where appropriate, facilitated with the support of a healthcare worker for those experiencing post exertional malaise or post exertional symptom flare.
Frota A X, et al[21]	Acute myocarditis, myocardial injury, and HF	The 2020 Brazilian Cardiovascular Rehabilitation Guideline states that these rehabilitation programs should include aerobic exercises, resistance directed to peripheral and respiratory muscles, as well as stretching and balance exercises, always being individualized to the capacity and clinical condition of the individual. The guideline based its recommendation on at least 150 minutes per week of moderate-to-vigorous physical activity, distributed over 3–5 sessions, and tailored according to the clinical and functional parameters.
Kersten J et al[22]	VTE, ischemic and nonischemic heart disease	Using CPET, it was discovered that most patients (65%) with cardiac (4.2%) or pulmonary vascular (5.8%) limitations and cardiovascular disease, including VTE, ischemic, and nonischemic heart disease. A number of patients also showed dysfunctional states, such as deconditioning (15.8%) or pulmonary mechanical limitation (9.2%), in part because of abnormal breathing patterns. In a large majority of the patients (65%), no limitation was shown.

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Author	CVD Complications in Post COVID-19 Patients	CR for Post COVID-19 Patients with CVD Complications
Zhou S et al[23]	Coronary heart disease, CHF, severe myocardial cell damage, MI, cardiac dysfunction, and arrhythmia	CR is important for patients with long-COVID. Physical activity advice, medication, and lifestyle changes are provided. A cross-section study solicited those 18 years and above to fill a survey of how physical activity made their symptoms. The results were quite varied, as 74.84% reported deterioration, and only 0.84% reported improved symptoms. The most related and frequently performed physical activity was walking, representing almost 50% of all reported. The patient with COVID-19 is supposed to be exposed to physical activity with caution and individualization, starting with simple activities like household chores and walking, and then a gradual progression should be intended toward short walks. Finally, a formal exercise training program is prescribed. Therefore, psychological support and psychiatric intervention should be a component of care, since the patient goes through the diverse stages of CR.
Boylan M et al[24]	Ventricular dysfunction, cardiac fibrosis, ventricular arrhythmias, cardiogenic shock, and sudden cardiac death.	It appears that providing psychological support and implementing psychiatric interventions may be beneficial during the process of cardiac rehabilitation.
Ostrowska A et al[25]	CVD	RT may be one of the most exciting prospects, since it is known to increase the functional ability of patients with acute or chronic respiratory conditions, as well as in patients with cardiac activity. The following paper is intended to intervene in the inadequacy of evidenced-based and practical recommendations on RT prescription in individuals who have been diagnosed with COVID-19, with a focus on the immune, respiratory, and cardiovascular systems.
Kawanaka H et al[26]	TCM	The individual was administered favipiravir and steroids, and subsequently underwent rehabilitation, which resulted in an improvement in their condition.
Calabrese M et al[27]	HF, cardiomyopathy, ACS, arrhythmias, and venous thromboembolism	Exercise programs, both in the hospital and home environment, can be either low, moderate, or high in intensity based on the condition of the patient. Examples of such programs are ET (3-5 times a week), IT (3-5 times a week), HITT (2-3 times a week), and RT (2-3 times a week).

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Buckley B J R. et al[28]	Acute myocardial infarction, HF, hypertensive disease	Although recently, there have been attempts to establish guidelines of return to exercise of the athletes after having COVID-19, at the moment, there is virtually no information concerning the exercise in the context of other effects and cardiac rehabilitation on the clinical outcomes with discharged COVID-19 individuals. However, the integral cardiac rehabilitation is now considered a cost-effective intervention for secondary prevention, with positive outcomes in a variety of cardiovascular conditions.
Halle et al[29]	Post-myocarditis, CHF	For the recreational and competitive athlete, more specific guidelines are needed for exercise beyond rehabilitation programs and an evaluation of sports eligibility and specific return-to-sport exercise programs.
Raman B et al[30]	ACS, AF, VT, HF, CAD, MI	The described patients who continue to exhibit symptoms may need such detailed assessment regarding their mental and physical or cognitive status, since this will be important in order to hasten referral to relevant services of rehabilitation, physiotherapy, psychology, occupational therapy, as well as social and welfare support, to decrease the burden on a patient.

* ACS , Acute Coronary Syndrome; BP, blood pressure; CAD, Chronic Artery Disease; CHF, Congestive Heart Failure; CPET, Cardiopulmonary Exercise Testing; CR, Cardiac Rehabilitation; CVD, Cardiovascular Diseases; DVT, Deep Venous Thrombosis; ET, Endurance Training; HF, Heart Failure; HITT, High Intensity Interval Training; HR, Heart Rate; ICU, Intensive Care Unit; ICT, Information And Communication Technologies; IHD, Ischemic Heart Diseases; IT, Interval Training; MI, Myocardial Infarction; PASC, Post-Acute Sequelae COVID-19 Syndrome; POTS, Postural Orthostatic Tachycardia Syndrome; RR, Respiration Rate; RT, Resistance Training; SpO_2, Peripheral Oxygen Saturation; TCM, Takotsubo Cardiomyopathy; TR, Tele-rehabilitation; VCR, Virtual Cardiac Rehabilitation; VO_2 max, Maximum Oxygen Volume; VTE, Venous Thromboembolic

DISCUSSIONS

Post COVID-19 condition, also known as "long COVID," is a constellation of chronic symptoms that some individuals begin to experience either at the time of infection with the coronavirus that causes COVID-19 or after the infection.[10] Rather, emerging evidence indicates that about 10% to 20% of individuals have a moderate- to long-term impact following recovery from their acute illness.[11] Post COVID-19 syndrome can affect individuals with a past of suspected or confirmed SARS-CoV-2 infection and is commonly manifested three months after the infection with the first symptoms of COVID-19 occurred and must have persisted for a minimum of two months and for which the symptoms cannot be plausibly attributable to another diagnosis.[10,12]

Table 1 shows the complications and CR in post-COVID-19 patients with CVD complications. The most commonly associated complications of CVD include myocarditis, arrhythmia, HF, ACS, and VTE. Therefore, the most effective way for doctors to control and maintain the condition of their patients is to educate them about exercise.

Prevalence and Types of Cardiovascular Complications

These cardiac complications in post-COVID-19 patients are increasingly reported, with instances of myocarditis and arrhythmias being increasingly reported across many investigational studies.[13,14,17,19] The long-term morbidity observed in these patient populations is significantly related to these complications. Myocarditis is the inflammatory state of the heart musculature that leads to arrhythmias, which in turn denotes a disturbance in the heart rhythm. For this reason, atrial and ventricular arrhythmias can be observed even in people with no history of any cardiac disease in the past, likely as a result of the direct implications of the SARS-CoV-2 virus on cardiac electrophysiology.[13,14,17]

Another common complication is HF.[14-16,27-30] This condition warrants close monitoring and multimodal rehabilitation in post-COVID-19 patients. Common comorbid complications require a multifaceted care approach that is both pharmacologic and non-pharmacologic for the best outcomes in improving cardiac function and quality of life.[30]

There is an increased incidence of VTE in the post-COVID-19 population.[13-15,22] Several papers reported the frequent occurrence of VTE, including DVT and Pulmonary Embolism (PE), in patients associated with a procoagulant state induced by the virus. At high risk of hypercoagulability, prophylactic and treatment-related anticoagulation strategies are used for these potentially life-threatening conditions. [22]

Many studies have directly reported the cause-effect relationship of respiratory complications as the leading cause of ACS, and the incidence of MI is significantly higher in COVID-19 survivors.[13,23,30] The infection-induced inflammatory response is supposed to accelerate thrombosis and atherosclerotic plaque rupture, and thereby MI. This in turn underlines the mandatory need for thorough assessment and management of cardiovascular risk in patients who have had COVID-19.[23]

Available evidence from the current literature indicates that post-COVID-19 cardiovascular complications are highly common and diverse, affecting many aspects of cardiac function and health. The increased incidence of such complications is related to the need for adequate cardiac monitoring and rehabilitation to reduce the long-term deleterious outcomes. Recent studies have examined the mechanisms that underlie these complications. For example, persistent inflammation, identified as one of the mechanisms and direct viral invasion of cardiac tissue, may be important in the pathogenesis of these cardiovascular issues. This emerging evidence further underscores the need for continued research toward a full understanding of the cardiovascular sequelae of COVID-19.[30]

Impact of Cardiac Rehabilitation (CR):

CR has shown enormous benefits post-COVID-19 in dealing with cardiovascular complications, improving clinical outcomes, and enhancing the quality of life of patients.

In this regard, CR plays an important role in dealing with challenges faced by patients.

a. Clinical Benefits

It would be essential to improve post-COVID-19 if he or she had undertaken CR. VO2 max has been shown to increase significantly in individuals who enroll in CR.[6] In post-COVID-19, that is necessary to regain the functional capacity and physical endurance that were lost to the illness. Another benefit is that mortality and rehospitalization rates are lower in those participating in CR programs. It has been demonstrated that those enrolled in CR programs experienced a 25-30% reduced risk of cardiovascular mortality and a 30% incision in rehospitalization within 12 months of the rehabilitation period.[8] This clearly indicates that CR has to save lives within the post-COVID-19 population. In addition, exercise interventions should be programmed with care, as many post-COVID-19 patients have reported a worsening of symptoms if exposed to unstructured physical activity.[23]

b. Psychological Benefits

A major component of CR is psychological support for coping with the mental health issues associated with heart disease. The psychological treatment embedded in CR curricula will help patients overcome their anxiety, depression, and other stress-related issues. This holistic approach further improves physical and mental health. In fact, the total programs of CR, inclusive of cognitive training and stress management, as well as lifestyle adjustments, lead to general well-being, which is an improvement in the quality of life and makes more thorough recovery possible.[24]

c. Socio-Economic Benefits

CR programs are both clinically effective and cost effective. Importantly, CR, especially through TR, reduces the costs associated with health by reducing the number of in-person visits and the number of times people are readmitted to hospitals. This is the essence of sustainable health solutions throughout and after the pandemic. The economic gains of CR accrue from improved accessibility, notably of patients in remote areas or who cannot visit in-person.[32] The transition to TR and VCR has brought the programs closer, leading to better access, and the target numbers can, therefore, be better received, leading to improved public health outcomes.

d. Innovative Approaches

The ongoing COVID-19 pandemic has considerably accelerated the adoption of TR in cardiac rehabilitation settings, where it has proven to be an effective adjunct in maintaining and improving patient engagement and compliance with rehabilitation protocols. The study results show that tele-cardiac rehabilitation (TCR) programs are sufficiently effective to improve clinical outcomes on par with traditional, in-person programs and provide the required flexibility under restrictive conditions created by a pandemic. This assures that the attention is continued for patients regarding the comprehensive rehabilitation, irrespective of any obstacles, be they external.[34]

These findings underline the multidimensional benefits of cardiac rehabilitation (CR) in post-COVID-19 care and show the importance of these benefits for any improvement in physical and psychological health as well as a reduction in the cost of medical services. In such light, addition of telemedicine in CR-

based programs would therefore mark a very substantial step where the interested parties would still see the patients provided with total care during such times, described by persistent public health challenges.[34]

Several studies and reviews have included similar themes, talking about the need for sustainable and pragmatic models for TCR in view of imminent and repetitive waves of the pandemic, hence the role of remote monitoring and telehealth services in sustaining patient care.[21,32]

e. Home-Based Cardiac Rehabilitation (HBCR)

Owing to limited access to healthcare facilities, home-based cardiac rehabilitation (HBCR) is more common than center-based cardiac rehabilitation (CBCR). Through this model, patients in numbers untold have the possibility of continuing their way to rehabilitation, with the final goal of being healthier in times when hospital visits have been restricted. Adult programs, which have embraced TR within CR, have been associated with efficient improvements in VO2 max and proven effective, safe, and further translate into maintaining an active lifestyle over a moderate term.[13,14] Existing literature recommends this hypothesis, making suggestions that RT could be a potentially safe and feasible activity that is possibly time-efficient and easy to implement in settings.[25]

Tailored Rehabilitation Programs

Rehabilitation programs are individualized because they meet the specific needs of individuals suffering from complications associated with the cardiovascular system as a result of COVID-19. These programs are tailored to the clinical and baseline health status of each patient individually, and continue to confer effectiveness and integrity to the rehabilitation process.

a. Personalized Exercise Regimens

Aerobic and resistance exercises improve cardiovascular and muscle strength. An individual approach is very personal; therefore, it is conducted according to the starting level of fitness of the individual and the progress made during the rehabilitation process. Starting at low intensity and eventually progressing to moderate and high intensity is a way of preventing fatigue and making the recovery safe.[6] Graduality in the process is very important in rebuilding the patient's endurance and physical capacity so as not to experience risk of injury or over-fatigue.[15]

There is an eight-week requirement for the exercise program in cardiopulmonary rehabilitation and supervised exercise that properly incorporates aerobics and resistance exercise, tailored to the severity of cardiovascular conditions of an individual. All programs will assist in meeting the needs of post-COVID-19 patients and help them transition to compensate for and adapt to the physiological changes that the disease has accrued. The structured exercise program will enhance cardiovascular health, physical endurance, and general well-being.[20]

A more individualized return-to-sport program should be developed, especially for athletes with infection. Advice on training should be provided to athletes to prevent inappropriate sports and to safely return to activity free of injury risks. This part of rehabilitation is particularly valuable for patients for whom physical activity is intended to be a key part of their life.[28,29]

b. Psychological and Cognitive Training

Special psychological support for this rehabilitation, such as the problems of anxiety, depression, and stress using cognitive-behavioral therapy (CBT) and some other psychological cures, greatly makes the process of rehabilitation more effective.[24] Based on the cognitive training programs' important role in the development of mental agility and coping mechanisms, it is so evident that they prove to be very important for the patients recovering from serious illnesses. This integral approach ensures working on physical and cognitive deficits during rehabilitation, which is stimulating and holistic for balanced and effective recovery.

c. Individualized Health Education

Education is an integral part of personalized CR programmes. The major educational goal for patients should be an understanding of their medical condition, the process of rehabilitation, and changes in the lifestyle required to live healthily. Patient education enables them to develop self-efficacy and a long-term commitment to practicing healthy behavior, which in turn enhances maintenance after rehabilitation. [29]

d. Comprehensive Multidisciplinary Approach

A comprehensive rehabilitation program is needed to approach everything in a multidisciplinary manner. This program, together with skills in cardiology, physiotherapy, psychology, and nutrition, will take care of almost all aspects of a patient's health and ensure improved overall results. The same virtual rehabilitation program and telehealth services can also be used to monitor and modify an ongoing exercise regimen in line with the feedback and progress of the patient at the other.[14,24,25,30]

e. Monitoring and Feedback

Regular monitoring of vital health parameters in the form of HR, BP, and Spo_2 is crucial for safety during rehabilitation and allows timely adjustments in the rehabilitation plan.[15] Monitoring allows continuous assessment to allow dynamic adaptive strategies in regard to the progress of patients undergoing a post-COVID-19 recovery process to rehabilitation programs. Flexible rehabilitation should consider the changing needs of the patients to ensure sustainable recovery and better health. Monitoring could be done through wearable technology and remote monitoring tools to provide real-time feedback and support.[30]

Challenges and Future Directions

A CR program for these patients presents several implementation challenges that must be addressed to ensure that patient outcomes are optimized. Therefore, further research should address these disparities in implementation and outcomes.

a. Challenges

The major challenge that has constantly faced the implementation of a CR program for post-COVID-19 patients is limited access to health facilities. The condition further made it difficult for the CR programs to be accessed directly in person by the patients owing to the restrictions and high level of spread of this condition. Most of these limits are very crucial in enabling most of the patients to have access to their care in a frequent manner, as most recent research highlights.[32]

TR is another likely equivalent to some of these problems. However, there are barriers to the effective implementation of TR programs, including access to technology, problems

with connectivity, and to some extent, digital literacy related to patients and providers. Such obstacles seriously damage the effectiveness of TR programs in total replication and imitation of live sessions.[21]

Patient engagement and compliance within CR programs are of heightened importance, especially in home or virtual rehabilitation programs, which presents another significant challenge. The lack of support structures within the organizational environmental setup at health facilities would decrease the motivation and involvement of patients in rehabilitation programmes. An effectively sustaining patient compliance and engagement approach needs to be innovative in such a way that the patients continue being motivated and involved in rehabilitation programs.[14]

Hence, adequate resources, whether in monetary terms, trained labor, or equipment, are pivotal to the success of a CR program. Sufficient support from the health care system means these programs can be retained and thus support the needs of its probable candidates.[8]

b. Future Directions

Future CR research should focus on facilitating TR to become more accessible and personable for post-COVID-19 patients. This will include advancing further into the use of available technologies such as useable mobile tools and health applications, which are inherently compatible with around-the-clock monitoring and support for patient rehabilitation programs.[20] The above will provide better feedback in real time and create the possibility for personal adjustments of the next rehabilitation plan, which has been considered to be beneficial for the overall effectiveness of the CR program.

Therefore, personal rehabilitation programs must be improved by considering the features of their implementation in post-COVID-19 patients. The development of tailored programs, protocol implementation, psychological support strategies, and educational materials to address specific patient problems is necessary. In light of the above, personalization seems to be a recommended approach in increasing CR effectiveness in such a way that each patient would have a rehabilitation program appropriate to his or her individual health conditions and needs.[30]

There face major mental health challenges for the post-COVID-19 patient. Such psychological support should be integrated into CR programs. Future research is required to study the feasibility of remotely providing mental health interventions and their impact on the general outcomes of rehabilitation. Additionally, this will integrate aspects of health in mental recovery, aspects that are equally as important as physical rehabilitation.[35]

For the same reason, well-designed longitudinal studies are needed to evaluate the continued benefits of CR programs in post–COVID-19 patients. This is the only way long-term clinical outcomes, quality of life, and health behaviors are tracked over time in longitudinal studies and will culminate in the evidence needed for the CR program's effectiveness. Long-term data would be invaluable in fully understanding the influence CR has on long-term recovery and health.[27]

There is a need to push for policy changes and an upsurge in funding support for CR programmes. This will also enhance their reach and, in the process, ensure that the programs radically change and are sustainable in post-COVID-19 treatment.[29]

With the resolution of such problems, CR programs are bound to be very effective and accessible after post-COVID-19. To improve not only patients' outcomes but also the preparedness of the healthcare system, these are bound to help in the long-term effects of the COVID-19 pandemic.

CONCLUSIONS

In summary, this review emphasizes the need for CR programs that are carried out as early as possible, comprehensively, and individually to effectively manage cardiovascular complications that arise in post-COVID-19 patients. This rehabilitation program is adapted to the patient's condition and has become important, including physical and psychological support. The shift towards telerehabilitation offers practical solutions to pandemic-related challenges, so as to ensure ongoing patient care. Ongoing research and adaptation of CR programs are essential to meet the growing needs of post-COVID-19 patients. CR programs are essential for improving the quality of life and reducing mortality rates.

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