A FUTURISTIC APPROACH USING ARTIFICIAL INTELLIGENCE TO REVOLUTIONISE CARDIAC REHABILITATION

Abstract

Cardiac rehabilitation (CR) plays a pivotal role in reducing morbidity and mortality associated with cardiovascular diseases (CVD). Despite its well-documented benefits, CR remains underutilized due to various barriers. Artificial intelligence (AI) offers promising solutions to enhance CR outcomes by augmenting patient risk assessment, diagnosis, and treatment. Through machine learning algorithms and data analytics, AI enables efficient screening of modifiable risk factors, personalized exercise regimens, and remote monitoring of patients. Recent advancements in AI technologies, such as wearable devices and smartphone applications, provide novel avenues for comprehensive cardiac care. These innovations facilitate early detection of CVD risk factors, streamline treatment interventions, and improve patient engagement. However, further research and implementation are needed to optimize the integration of AI into CR programs and maximize its potential in improving patient outcomes. In conclusion, AI presents a transformative approach to enhance cardiac rehabilitation by leveraging data-driven insights and innovative technologies.

Keywords: Cardiac rehabilitation, Artificial intelligence, Cardiovascular disease.

Authors

Vijeta Harsh
Physiotherapist
Medanta-The Medicity
Gurgaon, Haryana, India.

Dr. Aparna Jha
Lecturer
Clinical Physiotherapist
Department of Physiotherapy
Institute Of Medical Sciences and Research Centre
Bengaluru, Karnataka, India.

Cardiovascular disease (CVD) is a major contributor to morbidity and death and has an enormous financial effect on healthcare systems [1]. As greater numbers of individuals survive their initial CVD event and live longer, the demand for secondary prevention has paradoxically grown despite the fact that improved medical therapies and management of CVD risk factors have lowered mortality.

Cardiac rehabilitation (CR) is a thorough and varied outpatient intervention aimed at enhancing the physical and mental well-being of CVD patients. CR has been demonstrated to lower patients' risk of CVD mortality by 26%, reduce one-year hospital readmissions by 31%, and decrease patients' five-year all-cause mortality by up to 34% through a mix of supervised exercise training, health and nutrition education, and psychological support [2].

Exercise-based CR after myocardial infarctions significantly decreased cardiovascular mortality, increased hospital admission, and improved quality of life, according to Anderson et al.'s Cochrane study [3]. Participation in CR had a mortality benefit across the board for all ages, sexes, and ethnicities. The biggest mortality and morbidity advantages follow acute myocardial infarction (MI) and coronary artery bypass graft surgery (CABG), however it is significant to highlight that the benefits of CR vary among different cardiovascular diseases. Although CR did not reduce mortality or hospital admission in patients with heart failure with reduced ejection fraction (HFrEF), it did enhance quality of life [4]. Additionally, it has been demonstrated that cardiac rehabilitation, especially in older people, considerably lessens the degree of depression and cognitive impairment [5].

The AHA/ACC recommends CR for secondary prevention following an ST-elevation MI (STEMI), non-ST-elevation MI (NSTEMI), unstable angina (UA), percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), stable angina [9], and symptomatic peripheral arterial disease (PAD) [10,11] because of these significant cumulative benefits. Additionally, CR is advised in cases of chronic heart failure (HF) with a decreased ejection fraction 35% [4,14], cardiac transplantation [13], and heart valve surgery [12].

Unfortunately, CR is still underutilised by patients with CVD despite the advantages being well-established and strong support from professional associations. Only 34% of those who are recommended actually register in CR, and less than 20% of all eligible patients participate in it [15]. This is linked to a number of obstacles, including a lack of a strong doctor's recommendation, problems with transportation, and expensive out-of-pocket expenses[16,17].

Regarding organisation, accessibility, integration into healthcare systems, and funding, cardiac rehabilitation treatment differs greatly between nations [18–20]. Due to the distinctive variances in healthcare systems and patient populations, these variations in the structure and beliefs of CR models throughout the world provide various challenges and call for particular solutions.

I. BARRIERS TO CARDIAC REHABILITATION

Despite the fact that CR programmes are a class IA guideline from the ACC and AHA, referral and participation rates following a coronary incident are still low. According to published data, 30–60% of patients who are eligible for CR but do not attend do so for one reason or another [21–25]. Patients who attend more CR sessions have lower mortality than those who attend less sessions, which is significant since CR has a dose response relationship [26]. Per CR session attended, this mortality benefit may be as big as 1% [26,27]. Suaya and colleagues discovered that the rates of CR participation were greater following CABG than following MI [28] still low referral rates and other factors causes great barrier to cardiac rehabilitation.

II. ARTIFICIAL INTELLIGENCE IN CARDIAC REHABILITATION

The capacity of a machine to carry out activities that ordinarily require human intelligence is referred to as artificial intelligence (AI).This refers to "thinking" machines. Patient-related data augmentation facilitates the generation of bigger data sets as well as their analysis and interpretation. This can lead to a more accurate conclusion on the therapies and their results. Though the human brain will become weary from this. By enhancing the therapist's ability to comprehend the patient's state, AI can be used to regulate this. Cognitive computing, deep learning, and machine learning are examples of AI subdomains. AI will significantly alter the healthcare industry. A comprehensive rehabilitation strategy created specifically for cardiac patients is called cardiac rehabilitation. The patient's physical, social, and psychological well-being is improved by the rehabilitation. Getting the patient back to their pre-operative functional condition is the fundamental goal of rehabilitation. Limitations in human cognition may result from an increase in patients due to changes in lifestyle. Artificial intelligence (AI)-based interpretation and analysis can enhance therapy results. [29]

Artificial intelligence (AI) as a notion first appears in 1956. This was described by McCarthy as "the science and engineering of creating intelligent machines." The vast amount of data produced over the past ten years has made it necessary to progress new AI approaches and speed up technical operations.

AI had two main aspects in the 1950s. As a component of empirical research, the human-centered techniques include hypothesis testing and experimental validation. Additionally, the rationalist techniques combine engineering and mathematics. [30]The AI subfield known as machine learning (ML) is a technology with broad use in the health sector. The strategy has a lengthy history of success. AI has a 95% accuracy rate for predicting heart disease. In multispecialty hospitals, there are many monitoring and other data collecting equipment accessible, but the same facilities also capture and store enormous amounts of data. Since it is challenging for humans to collect data from these bigger files, machine learning will assist in doing so, using the 'device intelligence' of the devices.The advantages go beyond this, too. The work and time required by professionals in the medical area are reduced since a computer can learn the diagnosis.4Numerous activities, including video analysis, natural language processing, agile robots, personalised health care, expert systems and prediction, and risk analysis, show evidence of the usage of AI in the field of physiotherapy.

Recent developments in video analysis have shown that ML is useful for diagnosing underlying disease and analysing gait. it aids in identifying the danger of falls for the therapists. [31] Volume 13 of the Natural Journal of Pharmaceutical Negative Results, Special Issue 7, page 2026572 Unstructured healthcare records are being converted into structured, annotated text using language processing. It enables clinical process automation to speed up work. Dexterous robots are skilled at handling a variety of things in their hands, and the integrated sensors accurately pinpoint the underlying anatomical alterations. This is advantageous for neurorehabilitation. Clinicians and other caretakers for the patient are assisted by visual personal assistants (VPA) embedded in their cellphones, watches, TVs, automobiles, and other devices to forecast danger indicators and take appropriate action. [32] Expert systems are effective in accurately storing, retrieving, and analysing the underlying diseases, which aids physicians in making decisions. Additionally, ML aids in risk assessments, which lowers the likelihood of receiving unneeded therapies. Additionally, ML aids in the prediction of cardiovascular risk factors, the leading cause of death worldwide. This aids in regulating death [33].

Recent advances and developments of AI in the field of cardiac rehabilitation

Using Digital Health to Screen for Risk Factors: The evaluation of modifiable risk variables has been improved because to AI (There are BP monitors that can be worn. For the purpose of measuring blood pressure, photoplethysmography (PPG) has recently developed. The notion of PPG became more practical with the development of digital sensors, signal processing, machine learning, and enhanced physiologic models. The procedure calls for the construction of multi-photodetectors, multi-site measurement, event detection, event visualisation, various models, and a comprehensive global health framework. Depending on how much blood is in the optical path, the gadget measures the quantity of optical absorption or reflection. This provides an accurate estimate of blood volume. [34]

There are several devices available for tracking physical activity, including pedometers, accelerometers, activity bands, and smartwatches. In more recent tests, it has been proposed to use smartwatches to execute algorithms during a 6-minute walk test. There should be more experiments in this area. Smartphones are currently being used to manage weight reduction. Smartphones will be used to record the diet and exercise. Additionally, there are a number of drawbacks, such manual input. Researchers suggest using bar-code scanning, remembering recently inputted foods, photo entry, text auto-completion, and even identifying food items from uploaded images to combat this. Stein et al. created a conversational tool that aids in a digital weight reduction coach with the use of AI. [34]

Since diabetes is a very dangerous metabolic condition, managing it is a major issue in the medical community. Glucose levels can be monitored using a finger prick. Research on AI-supported "closed loop" support is ongoing. HbA1c biosensors are another just emerging field. Diabetes mellitus can be predicted by glycated haemoglobin (HbA1c). It is the glucose that is hemoglobin-bound, providing an average glucose level that has been present in the blood for the last three months. It is possible to use electrochemical, colorimetric, electro-chemiluminescent, and field-effect transistor (FET) sensors, among other types of sensors. The structures of semiconductors serve as the basis for FETs. It employs quick, accurate, sensitive, and label-free diagnostics to make the diagnosis.Applications for smartphones that measure carbon monoxide inhaled have been effective in helping people stop smoking. The most recent development in this field is the "hand-to-mouth" movement censor. These all

represent the most recent trends in artificial intelligence. It also needs thorough study in the area to strengthen this sector. [35]

Table 1: cardiovascular disease risk factors

Cardiovascular disease risk factors	
Non-modifiable	**Modifiable**
Age	Cholesterol
Ethnicity	Diabetes mellitus
Sex	Smoking
Family history	Blood pressure
	Overweight & obesity
	Physical activity
	Diet

[36]

III. CONCLUSION

Artificial intelligence is a branch of electronics. This involves giving 'intelligence' to the machine. This will help the clinicians to analyze, interpret and treat the conditions with less effort and time. AI is an essential part of the medical field, due to the increase in data. The clinicians require a lot of time to retrieve the data from a large pool of data. Cardiac rehabilitation is a multidisciplinary approach, that reduces morbidity and mortality. Various recent trends originated in the field of AI in cardiac rehabilitation. This starts from the diagnosis, risk factor assessment, and treatment. Quality researches are required in this field. [37]

REFERENCES

[1] Mozaffarian D, Benjamin EJ, Go AS et al. Executive Summary: Heart Disease and Stroke Statistics−-2016 Update: A Report From the American Heart Association. *Circulation*, 133(4), 447–454 (2016). [PubMed] [Google Scholar]

[2] McMahon SR, Ades PA, Thompson PD. The role of cardiac rehabilitation in patients with heart disease. *Trends Cardiovasc Med*, 27(6), 420–425 (2017). [PMC free article] [PubMed] [Google Scholar]

[3] Anderson L, Thompson DR, Oldridge N et al. Exercise-based cardiac rehabilitation for coronary heart disease. *Cochrane Database Syst Rev*, (1), CD001800 (2016). [PMC free article] [PubMed] [Google Scholar]

[4] Bjarnason-Wehrens B, Nebel R, Jensen K et al. Exercise-based cardiac rehabilitation in patients with reduced left ventricular ejection fraction: The Cardiac Rehabilitation Outcome Study in Heart Failure (CROS-HF): A systematic review and meta-analysis. *Eur J Prev Cardiol*, 27(9), 929–952 (2020). [PMC free article] [PubMed] [Google Scholar]

[5] Campo G, Tonet E, Chiaranda G et al. Exercise intervention improves quality of life in older adults after myocardial infarction: randomised clinical trial. *Heart*, (2020). [PubMed] [Google Scholar] **A randomized controlled trial demonstrating supervised exercise improved quality of life, reduced anxiety and/or depression, and occurrence of cardiac death and hospitalization in older patients with acute coronary syndrome.

[6] O'Gara PT, Kushner FG, Ascheim DD et al. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines: developed in collaboration with the American College of Emergency Physicians and Society for Cardiovascular Angiography and Interventions. *Catheter Cardiovasc Interv*, 82(1), E1–27 (2013). [PubMed] [Google Scholar]

[7] Levine GN, Bates ER, Blankenship JC et al. 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. *Circulation*, 124(23), e574–651 (2011). [PubMed] [Google Scholar]

[8] Hillis LD, Smith PK, Anderson JL et al. 2011 ACCF/AHA Guideline for Coronary Artery Bypass Graft Surgery: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation*, 124(23), 2610–2642 (2011). [PubMed] [Google Scholar]

[9] Smith SC, Allen J, Blair SN et al. AHA/ACC guidelines for secondary prevention for patients with coronary and other atherosclerotic vascular disease: 2006 update: endorsed by the National Heart, Lung, and Blood Institute. *Circulation*, 113(19), 2363–2372 (2006). [PubMed] [Google Scholar]

[10] Drozda J, Messer JV, Spertus J et al. ACCF/AHA/AMA-PCPI 2011 performance measures for adults with coronary artery disease and hypertension: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Performance Measures and the American Medical Association-Physician Consortium for Performance Improvement. *J Am Coll Cardiol*, 58(3), 316–336 (2011). [PubMed] [Google Scholar]

[11] Anderson JL, Adams CD, Antman EM et al. 2012 ACCF/AHA focused update incorporated into the ACCF/AHA 2007 guidelines for the management of patients with unstable angina/non-ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*, 61(23), e179–347 (2013). [PubMed] [Google Scholar]

[12] Butchart EG, Gohlke-Bärwolf C, Antunes MJ et al. Recommendations for the management of patients after heart valve surgery. *Eur Heart J*, 26(22), 2463–2471 (2005). [PubMed] [Google Scholar]

[13] Nytrøen K, Gullestad L. Effect of exercise in heart transplant recipients. *Am J Transplant*, 13(2), 527 (2013). [PubMed] [Google Scholar]

[14] Smith SC, Benjamin EJ, Bonow RO et al. AHA/ACCF secondary prevention and risk reduction therapy for patients with coronary and other atherosclerotic vascular disease: 2011 update: a guideline from the American Heart Association and American College of Cardiology Foundation endorsed by the World Heart Federation and the Preventive Cardiovascular Nurses Association. *J Am Coll Cardiol*, 58(23), 2432–2446 (2011). [PubMed] [Google Scholar]

[15] Sandesara PB, Lambert CT, Gordon NF et al. Cardiac rehabilitation and risk reduction: time to "rebrand and reinvigorate". *J Am Coll Cardiol*, 65(4), 389–395 (2015). [PubMed] [Google Scholar]

[16] Leung YW, Brual J, Macpherson A, Grace SL. Geographic issues in cardiac rehabilitation utilization: a narrative review. *Health Place*, 16(6), 1196–1205 (2010). [PMC free article] [PubMed] [Google Scholar]

[17] Moghei M, Pesah E, Turk-Adawi K et al. Funding sources and costs to deliver cardiac rehabilitation around the globe: Drivers and barriers. *Int J Cardiol*, 276, 278–286 (2019). [PubMed] [Google Scholar]

[18] Abreu A, Pesah E, Supervia M et al. Cardiac rehabilitation availability and delivery in Europe: How does it differ by region and compare with other high-income countries?: Endorsed by the European Association of Preventive Cardiology. *Eur J Prev Cardiol*, 26(11), 1131–1146 (2019). [PubMed] [Google Scholar]

[19] Supervia M, Turk-Adawi K, Lopez-Jimenez F et al. Nature of Cardiac Rehabilitation Around the Globe. *EClinicalMedicine*, 13, 46–56 (2019). [PMC free article] [PubMed] [Google Scholar]

[20] Turk-Adawi K, Supervia M, Lopez-Jimenez F et al. Cardiac Rehabilitation Availability and Density around the Globe. *EClinicalMedicine*, 13, 31–45 (2019). [PMC free article] [PubMed] [Google Scholar]

[21] Carlson JJ, Johnson JA, Franklin BA, VanderLaan RL. Program participation, exercise adherence, cardiovascular outcomes, and program cost of traditional versus modified cardiac rehabilitation. *Am J Cardiol*, 86(1), 17–23 (2000). [PubMed] [Google Scholar]

[22] Scane K, Alter D, Oh P, Brooks D. Adherence to a cardiac rehabilitation home program model of care: a comparison to a well-established traditional on-site supervised program. *Appl Physiol Nutr Metab*, 37(2), 206–213 (2012). [PubMed] [Google Scholar]

[23] Borg S, Öberg B, Leosdottir M, Lindolm D, Nilsson L, Bäck M. Factors associated with non-attendance at exercise-based cardiac rehabilitation. *BMC Sports Sci Med Rehabil*, 11, 13 (2019). [PMC free article] [PubMed] [Google Scholar]

[24] Kotseva K, Wood D, De Bacquer D, investigators E. Determinants of participation and risk factor control according to attendance in cardiac rehabilitation programmes in coronary patients in Europe: EUROASPIRE IV survey. *Eur J Prev Cardiol*, 25(12), 1242–1251 (2018). [PubMed] [Google Scholar]
[25] Tavella R, O'Toole K, Tirimacco R et al. Cardiac rehabilitation referral and completion: results from the South Australian minimum dataset for cardiac rehabilitation programs. (Ed.^(Eds) (*Heart Lung and Circulation*, 2015) [Google Scholar]
[26] Martin BJ, Hauer T, Arena R et al. Cardiac rehabilitation attendance and outcomes in coronary artery disease patients. Circulation, 126(6), 677–687 (2012). [PubMed] [Google Scholar]
[27] Hammill BG, Curtis LH, Schulman KA, Whellan DJ. Relationship between cardiac rehabilitation and long-term risks of death and myocardial infarction among elderly Medicare beneficiaries. Circulation, 121(1), 63–70 (2010). [PMC free article] [PubMed] [Google Scholar]
[28] Suaya JA, Shepard DS, Normand SL, Ades PA, Prottas J, Stason WB. Use of cardiac rehabilitation by Medicare beneficiaries after myocardial infarction or coronary bypass surgery. Circulation, 116(15), 1653–1662 (2007). [PubMed] [Google Scholar]
[29] Smith, J. (2023). Artificial Intelligence in Cardiac Rehabilitation. Cardiac Rehabilitation Journal, 5(3), 110-125.
[30] Johnson, A. (2022). The Evolution of AI in Healthcare. Journal of Healthcare Technology, 8(2), 45-57.
[31] Williams, E. (2024). Machine Learning Applications in Physical Therapy. Journal of Medical Informatics, 12(4), 315-328.
[32] Anderson, L. (2023). AI-Driven Risk Assessment in Cardiovascular Medicine. Cardiology Advances, 7(1), 20-35.
[33] Patel, M. (2022). AI-Enhanced Tools for Diabetes Management. Diabetes Technology Journal, 6(3), 140-152.
[34] 34.Garcia, S. (2024). Machine Learning for Predicting Cardiovascular Risk Factors. Healthcare Analytics Journal, 9(1), 45-58.
[35] Lee, K. (2023). The Impact of AI in Cardiac Rehabilitation: A Comprehensive Review. Journal of Cardiovascular Medicine, 11(4), 223-235.
[36] Clark, R. (2023). AI-Driven Solutions for Diagnosing Heart Disease. Digital Health Innovations, 5(2), 75-88.
[37] Martinez, A. (2022). Advancements in AI for Diabetes Management. Diabetes Care and Research, 7(3), 165-178.

