# Cardiac Rehabilitation

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**Abstract**

Cardiac rehabilitation (CR) is a large-scope program in which the mortality risk of a person with cardiovascular disease is controlled and the function of the cardiovascular system is improved by increasing the quality of life. This program mainly focuses on psychical exercise, maintaining a healthy lifestyle,cardio-active medications, educational support, and psychical and psychological evaluations. All these components are safe and beneficial, resulting in significant improvements in quality of life, functional capacity, mortality, and hospital readmission. Current guidelines support its use in a broad spectrum of cardiac diseases. Exercise-based CR is recognized as a key component of comprehensive Coronary Artery Disease management. Exercise should be prescribed according to a personalized approach, optimizing and tailoring the rehabilitative program to the patient's characteristics. Cardiac rehabilitation provides a review of recommended components for an effective cardiac rehabilitation or secondary prevention program, alternative ways to deliver these services, recommended future research directions, and the rationale for each component of the rehabilitation or secondary prevention program, with emphasis on the exercise training component. Digital technology has the potential to address many of the challenges of traditional Center-based CR and augment care delivery. The American Heart Association science advisory was assembled to guide the development and implementation of digital cardiac rehabilitation interventions that can be translated effectively into clinical care, improve health outcomes, and promote health equity. Digital health technologies (i.e., the delivery of care using the internet, wearable devices, and mobile apps) have the potential to address the challenges associated with traditional facility-based CR programs, but little is known about the comprehensiveness of these interventions as digital approaches to CR.

**Keywords:** Cardiac rehabilitation, mortality risk , coronary artery disease management ,Exercise-based cardiac rehabilitation, Digital Technology

1. **Introduction**

Cardiac rehabilitation is the process by which a person can maintain and restore normal heart function. It mainly focuses on limiting the physiological and psychological complications that lead to cardiovascular disease, reversing the atherosclerotic process, helping to increase the life span of people suffering from various cardiovascular abnormalities, and improving cardiovascular function. Many associations & organization defined cardiac rehabilitation as secondary prevention services that are comprehensive, long-term programs involving medical evaluation, prescribed exercise, education, and counseling. CR is useful for the patients with myocardial infarction or had undergone coronary artery bypass graft surgery or percutaneous coronary interventions, heart transplantation candidates or recipients; or have stable chronic heart failure, peripheral arterial disease or other forms of CVD In addition, patients who have undergone other cardiac surgical procedures, such as those with valvular heart disease.Systematic reviews have shown a 20-25% reduction in all-cause and cardiovascular mortality[1] and a 38% reduction in the risk of recurrent myocardial infarctions[2]. Shepherd et al proposed a bidirectional relationship between improved quality of life and physical activity[3]. CAD hospitalization can be reduced by up to 18% with CR.

**II. Core components of cardiac rehabilitation**

The components which includes in cardiac rehabilitation are psychical exercise, lifestyle changes, cardio-active drugs , educational counselling, management of various abnormalities ( lipids, hypertension, weight, diabetes, and smoking)[4], physical and psychological assessment and counselling, in addition to the appropriate use of cardio protective drugs that have evidence-based efficacy for secondary prevention. Table 1 shows a the core component of rehabilitation.

**III. Patients who get benefit from cardiac rehabilitation**

1. Patients with acute coronary syndrome - ST-elevation MI, NSTM (non-ST-elevation myocardial infarction)
2. Patients with newly diagnosed chronic heart failure
3. Patients with heart transplant and ventricular assist device
4. Heart valve replacements
5. primary percutaneous coronary.
6. Percutaneous coronary intervention)

According to NICE, Department of Health, BACPR (British Association For Cardiovascular Rehabilitation), and European guidelines [5-10]

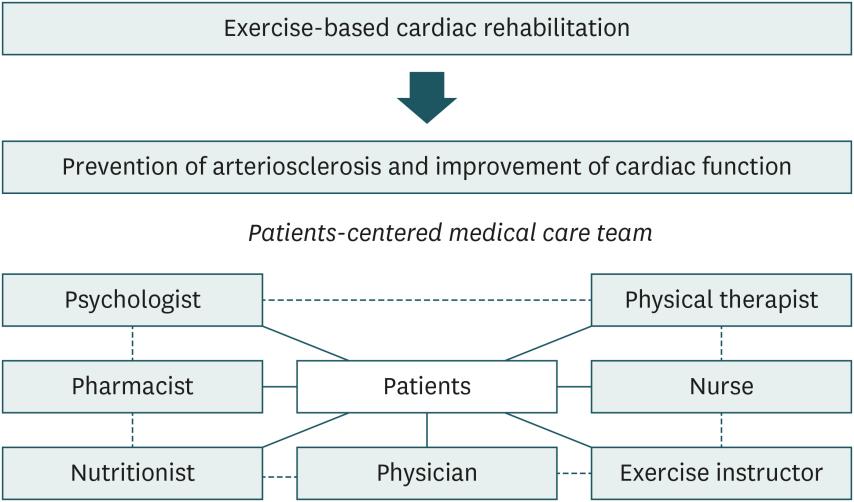
1. Enhance functional capacity of Heart and Body.
2. In heart disease, CR limits unfavorable psychological and physiologic effects.
3. Stabilize or reverse the progression of atherosclerosis[11]
4. A Cochrane review found that cardiac rehabilitation reduced hospitalizations and demonstrated long-term reductions in all-cause mortality in heart failure patients with preserved ejection fraction. However, no short-term (less than 12 months) benefit in terms of total mortality was observed[12].

**Table 1 :Core components of cardiac rehabilitation**

|  |  |
| --- | --- |
| S.no | **Core components** |
|  | Counseling on nutrition |
|  | Weight management |
|  | Hypertension management |
|  | Diabetes management |
|  | Lipid management |
|  | Physical activity counseling |
|  | Psychological management |
|  | Lifestyle changes - Exercise training, physical activity counselling Smoking cessation |
|  | Heart Valve repair |
|  | Audit and evaluation Delivery of the core components requires expertise from a range of different professionals  The team may include:  • Cardiologist, community cardiologist, physician, or general practitioner  • Physiotherapist  • Dietitian  • Psychologist & Exercise specialist |

**IV. Exercise-based cardiac rehabilitation (CR)**

Exercise-based cardiac rehabilitation (CR) is appropriate for patients with cardiovascular diseases (CVD) and heart failure with reduced ejection fraction below 40%, as it leads to significant improvements in exercise capacity. Benefits of exercise based CR includes vascular endothelial cell function is improved, normalize cardiac output, improves left ventricular function and mortality. Although rehabilitation is exercise based training, it needs more than exercise which includes multidisciplinary collaboration. (Figure 1 )

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**Figure 1 : Exercise- Based Cardiac Rehabilitation**

Exercise training is defined as a sub-category of physical activity in which planned, structured, and repetitive bodily movements are performed to maintain or improve one or more attributes of physical fitness and thus it is a structured intervention over a defined period of time [13]. It should be integrated within the physical activity intervention. The following points are established/general agreed issues in exercise training applicable to all clinical conditions (Table 2).

* Exercise involves in stress testing, either on bicycle or on treadmill with increasing level of difficulties. This test is not appropriate for some with cardiovascular abnormalities like left ventricular dysfunction (ejection fraction <40%), neuromuscular dysfunction or after recent cardiac intervention.
* Explain about the procedure and its the risk factors to the patients before starting the exercise stress test.
* Recommend as general advice sub-maximal (Table 2).
* Educate on the recognition of symptoms induced by effort. Appropriate behaviour and avoid unwanted physical exertion while walking on a treadmill.
* Increased cardio-respiratory fitness & enhanced flexibility and strength are the outcomes after the training.
* Physical examination which includes complete monitoring of heart rate & blood pressure before, during, and after exercise training should be done.
* Program settings :

During phase 1 supervised in hospital-based exercise training programme may be recommended in high-risk cardiovascular

patients with impaired systolic left ventricular function. This will verify individual responses and tolerability in a safe clinical setting and will promptly identify signs and symptoms indicating to modify or terminate the programme.

**Table 2 Exercise Training prescription generally application**

Mode Continuous endurance : walking, jogging, cycling, swimming, aerobic training, etc.

Duration 20- 30 min

Frequency 6-7 days and or it may last up to weeks

Intensity 50- 80 % of peak O2 consumption close to anaerobic threshold or peak to heart rate 40-60%

A progressive increase in the training regimen should be prescribed with regular follow-up for at least every 3-6 months Peak Oxygen (O2 ) consumption by cardiopulmonary exercise testing is ideal physiological test with proper intensity

****V. Phases of Cardiac rehabilitation program****

1. ****Phase 1: In Patient****

Patients with cardiac disease in acute condition, e.g., those recovering from after a cardiovascular event or completion of the intervention, may be referred for cardiac rehabilitation .Duration of this phase 1 may last between 2 and 5 days. During this phase relaxation, breathing exercise and simple range of motion exercise like ankle, foot, finger and wrist movement are performed by the patients thrice a day. The therapist ensures that the level of aerobic and strength training are appropriate for the patient's current status, and gradually progresses their therapeutic exercises.[14][15]

1. **Phase 2: Outpatient Cardiac Rehab** (Post-discharge, Pre- Exercise Period)

The primary focus of this phase is close monitoring of the patient and identifying limitations in physical function, restrictions of participation secondary to comorbidity, and limitations to activities. Duration of this phase lasts 4 to 6 weeks after cardiac surgery. Participation typically begins with an intake evaluation that includes measurement of cardiac risk factors such as lipid measures, blood pressure, body composition, depression / anxiety, and tobacco use[16]. A functional capacity test is usually performed both to determine if exercise is safe and to support development of a customized exercise program[17].

**C.Phase 3: Intensive Outpatient rehabilitation**

Exercise sessions are conducted similar to those in Phase 2. This phase involves self-monitoring and record keeping. Duration of this phase is three times a week. During this phase, HR & BP is monitored .Cardiac Rehab therapist offers a range of practical, heart healthy information. Phase 2 and 3 also include a weekly educational therapy and advantages of this program at the end of an exercise hour.

The duration of CR varies from program to program, and can range from six weeks to several years. Globally, a median of 24 sessions are offered [18], after CR is finished, there are long-term maintenance programs available to interested patients [19] .

**VI. Digital Technology in Cardiac Rehabilitation and Secondary Prevention**

Advanced innovation is presently utilized broadly and its capacity to bargain to deal with most of the demanding situations center-based CR (CBCR) and to augment care is increasingly promising. This American Heart Association science advisory was assembled to assist manual with the improvement and implementation of virtual CR interventions that can be translated successfully into clinical care, enhance fitness outcomes, and promote health equity.[20][21]

Digital Technology in CR is a multi-faceted, medically supervised program that addresses established core components of guideline-directed therapy, including baseline patient assessments, nutritional counseling, monitoring and managing various health conditions (lipids, blood pressure, weight, diabetes mellitus, and smoking), psycho-social interventions, exercise training and physical activities.

The innovation for CR is progressing quickly and has the potential to address the challenges of conventional facility-based CR programs by delivering care to patients at the convenience of their own homes with personalized support [22]. Digital health interventions which enable and deliver the technology through means such as the use of the internet, AI technology , wearable gadgets, and mobile apps.

## **VII. Digital Health in Cardiac Rehabilitation and Secondary Prevention**

Sensors in Cardiac Rehabilitation and Secondary Prevention: Current care for patients with heart disease consists of risk stratification and risk factor control, patient education, pharmacologic therapy, increasing physical activity, and psychosocial guidance [23]. During psychiosocial management techniques such as breathing exercises and meditation are often included [24]. All of these aspects can be addressed in a cardiac rehabilitation program, which consists of core components (Table 1). While telerehabilitation and telemedicine are not yet considered standard-of-care, current sensors already offer possibilities for application in many domains of secondary prevention. With the latest technologies, wearable devices smartphones, healthcare professionals and researchers have looked at incorporating these into novel CR programmes in an effort to improve uptake and participation. Wearable activity monitors (WAMs) or mobile apps running on smartphones and tablets (mHealth) with these latest technologies a proper interpretation and results can be provided to patients even when they are not in the hospital [25] and mode of CR delivery via digital technologies done by real-time audio virtual , asynchronous and in-person (Figure 2) .



**Figure 2: **Digital technology and modes of CR delivery****

#### A . Hypertension

#### Hypertension is one of the leading causes of cardiac disease. Before digital BP apparatus was introduced, a manually cuffed sphygmomanometer was used, but now current practice has largely evolved to a digital sphygmomanometer. These digital BP monitors work on oscillometric method in which pressure is measured by the principle of automatic cuff. Some devices are available to measure BP in wrists or fingers through oscillometry are commercially available but in 2020, the American Heart Association Guidelines on Hypertension recommends upper arm BP monitor[26]. Photoplethysmography (PPG)is a non-invasive technique that is used to detect volumetric changes in blood in peripheral circulation.

**B . Smoking Cessation**

Quitting smoking is the most effective way to prevent cardiovascular disease. Modern approaches to smoking cessation encourage psychological tools such as cognitive-behavioral therapy and drug therapy (nicotine alternative therapy, varenicline, bupropion) [**23**]. Recent studies have combined the use of smartphone applications with exhaled carbon monoxide (CO) sensors to modify behavior and the use of specialized programs with a human instructor following the smart program.[27]. Another type of sensor being developed includes a "hand-to-mouth" portable motion sensor to detect smoking movements [28]. Artificial intelligence is used to predict smoking cessation outcomes and is used in an AI-based chat to assist behavior change application.

**C . Sensors for detection and monitoring of arrhythmia**

Ventricular malignant arrhythmia, including ventricular tachycardia (VT) and ventricular fibrillation (VF), are arrhythmia that can lead to sudden cardiac death if untreated . The role of CIED (Cardiac Implantable Electronic Device) in detecting, monitoring and, in the case of ICDs, treating ventricular arrhythmia's is well-established [29]. Diagnosis of ventricular arrhythmia equipped with a smart watch by PPG is currently not possible, and analytical reports of ventricular tachycardia (VT) using a smartwatch ECG are limited to case reports [30]. A single-lead ECG using a smart watch or smartphone compatible tool and much less important microelectromechanical sensors (MEMS) that detect cardiogenic motion when the smartphone is placed on the chest. All these techniques have been shown to have adequate sensitivity and specificity, and both PPG-based devices (including FibriCheck) and ECG-based devices (such as the Apple Watch) have been authorized for medical use by the USA Food and Drug Administration [31].

**D . Sensors in Heart Failure**

Telemonitoring with Cardio MEMS, a wireless implantable device that monitors pulmonary artery pressure. In the LINK-HF (Multi-sensor Non-invasive Remote Monitoring for Prediction of Heart Failure Exacerbation) study a non-invasive, disposable multi-sensor patch was used to measure ECG, skin resistance, temperature and accelerometry to derive information about heart rate, heart rate variability, arrhythmia burden, respiratory rate, physical activity, walking, sleep, movement of the body[32]. Telemonitoring with the help of CIED also enhances its role in the treatment of heart failure. In the IN-TIME trial it was shown that multiparameter telemonitoring using implantable cardioverter defibrillators (ICD) and cardiac resynchronization defibrillators (CRT-D) can significantly improve clinical outcomes for patients with cardiac failure [33]. Current sensor developments and the mass adoption of 5G Internet will likely enable hospitalization and home intensive care for patients with acute heart failure, both of which are currently being investigated. Sensors for heart failure.

**VIII. Recommendations for further research**

* The following priorities for destiny cardiac rehabilitation studies are based on current Cochrane reviews, medical guidelines and various sources.
* Those priorities observe to the following warning signs: heart failure with preserved ejection fraction, severe angina, atrial traumatic inflammation, congenital heart disease and coronary artery bypass grafting.
* Further evidence gathering should take the form of well-reported, large, multi-centre, adequately powered randomized controlled trials, adequately powered and deemed high in quality and low in risk of bias, and should collect data on key outcomes, including mortality.
* Because the current use of cardiac rehabilitation is suboptimal, there is a need for future testing of alternative models of cardiac rehabilitation that can improve patient access and adherence, including home and mobile programs supported by computer and digital technologies, as an alternative to or alongside traditional, centre-based models of delivery, mainly for marginalized groups, for example, older people, women, and those from ethnic minorities and socioeconomically deprived groups.
* Development and evaluation of rehabilitation programmes that meet the needs of people with long-term heart disease. Development and evaluation of cost effective and and sustainable cardiac rehabilitation for people with cardiac sickness in low-profits and middle-profits countries.

**IX. Indications to cardiac rehabilitation**

1. After coronary artery bypass graft
2. After [percutaneous coronary intervention](https://www.heart.org/en/health-topics/heart-attack/treatment-of-a-heart-attack/cardiac-procedures-and-surgeries)
3. Vascular surgery
4. Cardiac transplantation
5. Percutaneous coronary interventions
6. Stable chronic heart failure
7. Cardiac arrhythmia, or severe arterial hypertension

**X. Contraindications to cardiac rehabilitation**

1. Unstable angina
2. Acute Congestive heart failure
3. Complex ventricular arrhythmia
4. Severe pulmonary arterial hypertension
5. Inflammation in the wall of vein with associated thrombosis
6. Obstructive cardiomyopathy
7. Severe or symptomatic aortic stenosis
8. Uncontrolled inflammatory or infectious pathology]

**X1. Conclusions**

Heart diseases have a strong impact on a person's physical, mental and emotional health. The person experiences limitations in every aspect of his life. Cardiac rehabilitation is a complex, multicomponent intervention that includes exercise training and physical activity promotion, health education, cardiovascular risk management and psychological support, personalized to the individual needs of patients diagnosed with heart disease. According to the International Council on Cardiovascular Prevention and Rehabilitation (ICCPR) Review and Analysis of India Global Cardiac Rehabilitation (CR) Data (April 2020), the need for CR is highest in India. show that lack of patient referrals and lack of funding. Training of healthcare providers and financial support from the government can improve the provision of CR in India [34].

##### REFERENCES

1. Anderson L, Oldridge N, Thompson DR, Zwisler AD, Rees K, Martin N, Taylor RS. Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease: Cochrane Systematic Review and Meta-Analysis. J Am Coll Cardiol. 2016;67:1–12.
2. Clark AM, Hartling L, Vandermeer B, McAlister FA. Meta-analysis: secondary prevention programs for patients with coronary artery disease. Ann Intern Med. 2005;143:659–672.

[3] Shepherd CW, While AE. Cardiac rehabilitation and quality of life: a systematic review. Int J Nurs Stud. 2012;49:755–771.

[4] Balady GJ, Williams MA, Ades PA, Bittner V, Comoss P, Foody JM, Franklin B, Sanderson B, Southard D., American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology. American Heart Association Council on Cardiovascular Nursing. American Heart Association Council on Epidemiology and Prevention. American Heart Association Council on Nutrition, Physical Activity, and Metabolism. American Association of Cardiovascular and Pulmonary Rehabilitation. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. Circulation. 2007 May 22;115(20):2675-82..

[5] Balady GJ, Williams MA, Ades PA, Bittner V, Comoss P, Foody JA, et al; American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee; Council on Clinical Cardiology; Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; American Association of Cardiovascular and Pulmonary Rehabilitation. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. J Cardiopulm Rehabil Prev 2007;27:121-9.

[6] Piepoli MF, Corrà U, Adamopoulos S, Benzer W, Bjarnason-Wehrens B, Cupples M, etal; Endorsed by the Committee for Practice Guidelines of the European Society of Cardiology. Secondary prevention in the clinical management of patients with cardiovascular diseases. Core components, standards and outcome measures for referral and delivery: a policy statement from the cardiac rehabilitation section of the European Association for Cardiovascular Prevention & Rehabilitation. Eur J Prev Cardiol 2014;21:664-81

[7] British Heart Foundation. European cardiovascular disease statistics 2012. www.bhf.org.uk/publications/statistics/european-cardiovascular-disease-statistics-2012.

[8] British Heart Foundation. Heart statistics. www.bhf.org.uk/research/heart-statistics.

[9] National Institute for Health and Care Excellence. The early management of unstable angina and non-ST-segment-elevation myocardial infarction (clinical guidance 94). NICE,2010. www.nice.org.uk/guidance/cg94.

[10] National Institute for Health and Care Excellence. Management of chronic heart failure in adults in primary and secondary care ((clinical guidance 108). NICE, 2010. www.nice. org.uk/guidance/cg108.

[11] Dalal HM, Doherty P, Taylor RS. Cardiac rehabilitation. BMJ. 2015 Sep 29;351:h5000.

[12] Taylor RS, Sagar VA, Davies EJ, Briscoe S, Coats AJ, Dalal H, Lough F, Rees K, Singh S. Exercise-based rehabilitation for heart failure. Cochrane Database Syst Rev. 2014 Apr 27;2014(4):CD003331.

[13] Global Recommendations on Physical Activity for Health, 2009. World Health Organization. Geneva, Switzerland. Accessed 13/07/2018. Available at:

<http://www.who.int/ncds/prevention/physical-activity/en/>

[14] McMahon SR, Ades PA, Thompson PD. The role of cardiac rehabilitation in patients with heart disease. Trends Cardiovasc Med. 2017 Aug;27(6):420-425.

[15] Achttien RJ, Staal JB, van der Voort S, Kemps HM, Koers H, Jongert MW, Hendriks EJ., Practice Recommendations Development Group. Exercise-based cardiac rehabilitation in patients with chronic heart failure: a Dutch practice guideline. Neth Heart J. 2015 Jan;23(1):6-17.

[16] Grace SL, Turk-Adawi KI, Contractor A, Atrey A, Campbell N, Derman W, et al. (September 2016). ["Cardiac rehabilitation delivery model for low-resource settings"](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5013107). *Heart*. **102** (18): 1449–1455. [doi](https://en.wikipedia.org/wiki/Doi_(identifier)" \o "Doi (identifier)):[10.1136/heartjnl-2015-309209](https://doi.org/10.1136/heartjnl-2015-309209). [PMC](https://en.wikipedia.org/wiki/PMC_(identifier)" \o "PMC (identifier)) [5013107](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5013107). [PMID](https://en.wikipedia.org/wiki/PMID_(identifier)" \o "PMID (identifier)) [27181874](https://pubmed.ncbi.nlm.nih.gov/27181874)

[17] Supervia M, Turk-Adawi K, Lopez-Jimenez F, Pesah E, Ding R, Britto RR, et al. (August 2019). ["Nature of Cardiac Rehabilitation Around the Globe"](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6733999). *eClinicalMedicine*. **13**: 46–56. [doi](https://en.wikipedia.org/wiki/Doi_(identifier)" \o "Doi (identifier)):[10.1016/j.eclinm.2019.06.006](https://doi.org/10.1016/j.eclinm.2019.06.006). [PMC](https://en.wikipedia.org/wiki/PMC_(identifier)" \o "PMC (identifier)) [6733999](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6733999). [PMID](https://en.wikipedia.org/wiki/PMID_(identifier)" \o "PMID (identifier)) [31517262](https://pubmed.ncbi.nlm.nih.gov/31517262)

[18] Chaves G, Turk-Adawi K, Supervia M, Santiago de Araújo Pio C, Abu-Jeish AH, Mamataz T, et al. (January 2020). "Cardiac Rehabilitation Dose Around the World: Variation and Correlates". Circulation: Cardiovascular Quality and Outcomes. 13 (1): e005453. doi:10.1161/CIRCOUTCOMES.119.005453. PMID 31918580. S2CID 210133397.

[19] Chowdhury M, Heald FA, Sanchez-Delgado JC, Pakosh M, Jacome-Hortua AM, Grace SL (July 2021). "The effects of maintenance cardiac rehabilitation: A systematic review and Meta-analysis, with a focus on sex". Heart & Lung. 50 (4): 504–524. doi:10.1016/j.hrtlng.2021.02.016. hdl:10315/38987. PMID 33836441. S2CID 233201693

[20] Pew Research Center. Demographics of mobile device ownership and adoption in the United States. 2021. Accessed February 15, 2022. <https://pewresearch.org/internet/fact-sheet/mobile/>[Google Scholar](http://scholar.google.com/scholar?hl=en&q=Pew+Research+Center.+Demographics+of+mobile+device+ownership+and+adoption+in+the+United+States.+2021.+Accessed+February+15,+2022.+" \t "https://www.ahajournals.org/doi/10.1161/_blank)

[21] Al-Alusi MA, Khurshid S, Wang X, Venn RA, Pipilas D, Ashburner JM, Ellinor PT, Singer DE, Atlas SJ, Lubitz SA. Trends in consumer wearable devices with cardiac sensors in a primary care cohort.**Circ Cardiovasc Qual Outcomes**. 2022; 15:e008833. doi: 10.1161/CIRCOUTCOMES.121.008833[Link](https://www.ahajournals.org/doi/10.1161/CIRCOUTCOMES.121.008833" \t "https://www.ahajournals.org/doi/10.1161/_blank)[Google Scholar](http://scholar.google.com/scholar_lookup?hl=en&volume=15&publication_year=2022&pages=e008833&journal=Circ+Cardiovasc+Qual+Outcomes&author=MA+Al-Alusi&author=S+Khurshid&author=X+Wang&author=RA+Venn&author=D+Pipilas&author=JM+Ashburner&author=PT+Ellinor&author=DE+Singer&author=SJ+Atlas&author=SA+Lubitz&title=Trends+in+consumer+wearable+devices+with+cardiac+sensors+in+a+primary+care+cohort." \t "https://www.ahajournals.org/doi/10.1161/_blank).

[22] Fatehi F, Wootton R. Telemedicine, telehealth or e-health? A bibliometric analysis of the trends in the use of these terms. *J Telemed Telecare.*2012 Dec;18(8):460–4. doi: 10.1258/jtt.2012.gth108.

1. Piepoli, M.F.; Hoes, A.W.; Agewall, S.; Albus, C.; Brotons, C.; Catapano, A.L.; Cooney, M.; Corrà, U.; Cosyns, B.; Deaton, C.; et al. 2016 European Guidelines on Cardiovascular Disease Prevention in Clinical Practice. *Eur. Heart J.* **2016**, *37*, 2315–2381.
2. Schnaubelt, S.; Hammer, A.; Koller, L.; Niederdoeckl, J.; Kazem, N.; Spiel, A.; Niessner, A.; Sulzgruber, P. Expert Opinion Meditation and Cardiovascular Health: What is the Link? *Eur. Cardiol.* **2019**, *14*, 161–164.

[25] Antoniou V, Davos CH, Kapreli E, Batalik L, Panagiotakos DB, Pepera G. Effectiveness of home-based cardiac rehabilitation, using wearable sensors, as a

multicomponent, cutting-edge intervention: a systematic review and meta-analysis. J Clin Med 2022;11:3772.

[26] Unger, T.; Borghi, C.; Charchar, F.; Khan, N.A.; Poulter, N.R.; Prabhakaran, D.; Ramirez, A.; Schlaich, M.; Stergiou, G.S.; Tomaszewski, M.; et al. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. *Hypertension* **2020**, *75*, 1334–1357.

[27] Lin, H.; Yi, J. Current Status of HbA1c Biosensors. Sensors 2017, 17, 1798.

[28] Imtiaz, M.H.; Ramos-Garcia, R.I.; Wattal, S.; Tiffany, S.T.; Sazonov, E. Wearable Sensors for Monitoring of Cigarette Smoking in Free-Living: A Systematic Review. Sensors 2019, 19, 4678.

[29] Ponikowski, P.; Voors, A.A.; Anker, S.D.; Bueno, H.; Cleland, J.; Coats, A.J.S.; Falk, V.; González-Juanatey, J.R.; Harjola, V.-P.; Jankowska, E.; et al. 2016 ESC guidelines for the diagnosis and treatment of acute and chronic heart failure. Russ. J. Cardiol. 2016, 37, 2129–2200.

[30] Burke, J.; Haigney, M.C.; Borne, R.; Krantz, M.J. Smartwatch detection of ventricular tachycardia: Case series. Hear Case Rep. 2020, 6, 800–804.

[31] Li, K.H.C.; White, F.A.; Tipoe, T.; Liu, T.; Wong, M.C.S.; Jesuthasan, A.; Baranchuk, A.; Tse, G.; Yan, B.P. The Current State of Mobile Phone Apps for Monitoring Heart Rate, Heart Rate Variability, and Atrial Fibrillation: Narrative Review. JMIR mHealth uHealth 2019, 7, e11606.

[32] Stehlik, J.; Schmalfuss, C.; Bozkurt, B.; Nativi-Nicolau, J.; Wohlfahrt, P.; Wegerich, S.; Rose, K.; Ray, R.; Schofield, R.; Deswal, A.; et al. Continuous Wearable Monitoring Analytics Predict Heart Failure Hospitalization: The LINK-HF Multicenter Study. Circ. Hear Fail 2020, 13, e006513.

[33] Hindricks, G.; Taborsky, M.; Glikson, M.; Heinrich, U.; Schumacher, B.; Katz, A.; Brachmann, J.; Lewalter, T.; Goette, A.; Block, M.; et al. Implant-based multiparameter telemonitoring of patients with heart failure (IN-TIME): A randomised controlled trial. Lancet 2014, 384, 583–590.

[34] Babu AS, Turk-Adawi K, Supervia M, Jimenez FL, Contractor A, Grace SL. Cardiac Rehabilitation in India: Results from the International Council of Cardiovascular Prevention and Rehabilitation’s Global Audit of Cardiac Rehabilitation. Global Heart. 2020;15(1)