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SPECIAL ARTICLE
Digital health and innovation

Standards for cardiac telerehabilitation

A scientific statement of the European Association of Preventive Cardiology (EAPC) and the Association of Cardiovascular Nursing & Allied Professions (ACNAP) of the ESC, and the ESC Working Group on e-Cardiology

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Abstract

Participation in comprehensive, multidisciplinary cardiac rehabilitation programmes as part of secondary prevention is recommended for patients with cardiovascular disease. However, recent data reveal that participation in cardiac rehabilitation is only around 30%–40% of eligible patients in Europe. Key barriers are practical barriers such as limitations in transport or scheduling issues. In recent years, home-based cardiac rehabilitation, delivered by telerehabilitation, has been suggested as an alternative or adjunct to centre-based cardiac rehabilitation to increase access, adherence, and participation rates. Multiple trials have demonstrated the effectiveness and cost-effectiveness of cardiac telerehabilitation. Recently, the European Association of Preventive Cardiology (EAPC) of the European Society of Cardiology (ESC) has defined the presence of a cardiac telerehabilitation programme as one of the quality indicators for centres requesting accreditation. This document aims to provide a clear description of cardiac telerehabilitation and to provide minimal standards and core components to ensure the high quality of cardiac telerehabilitation in Europe.

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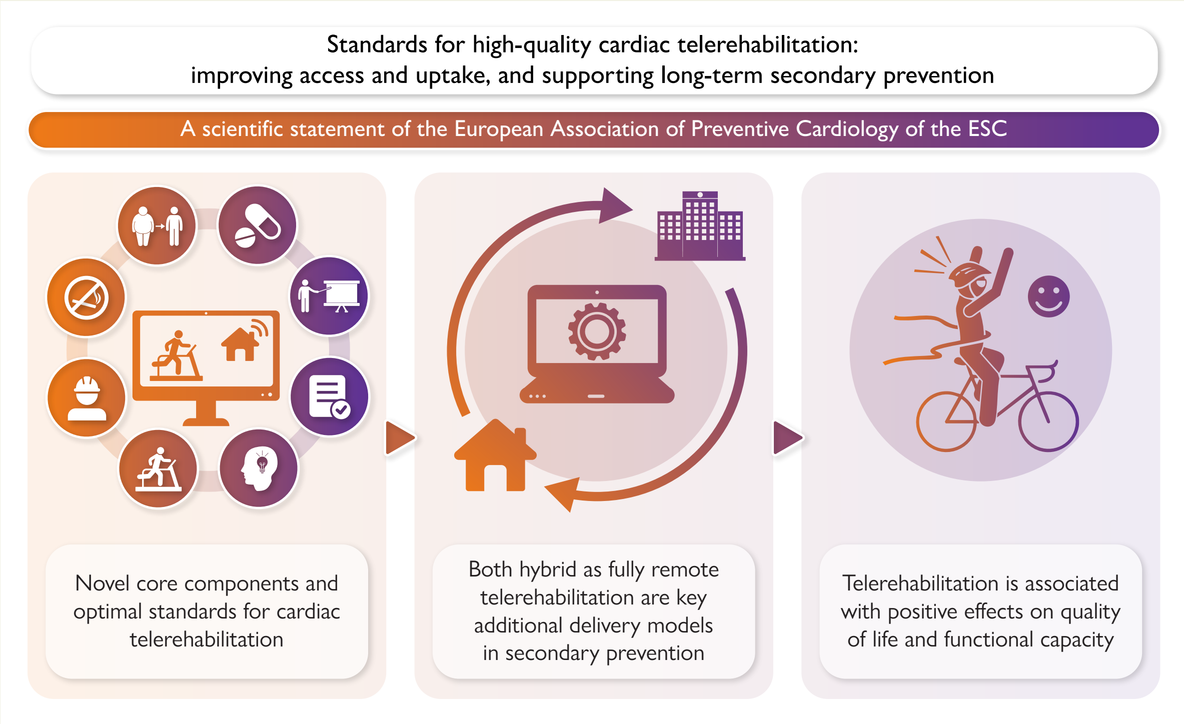
Graphical Abstract



High-quality cardiac telerehabilitation. Cardiac telerehabilition is the remote provision of all core components of comprehensive phase 2 cardiac rehabilitation. One of the main goals of cardiac telerehabilitation is to overcome barriers to attendance. Both hybrid programmes as hybrid programs exist. They should be used depending on the preferences and needs of the patient. Several studies have already showed positive effects on quality of life and exercise capacity. However, more research is still needed due to the small sample size, short duration and heterogeneity of most of the current published trials.

Keywords Telerehabilitation • Digital Health • Cardiac rehabilitation • Prevention • Telemonitoring

Introduction

Premature cardiovascular mortality is decreasing in most European countries due to improved medical care and prevention. However, the reduction in mortality rates has slowed down.[1] Suspected causes are the rising prevalence of obesity and diabetes, along with an ageing population.[1] Atherosclerotic cardiovascular disease (ASCVD) recurrence rates are high (up to 5%–15% in the first year after myocardial infarction), partially due to insufficient implementation of secondary prevention measures, as shown in the EUROASPIRE surverys.[2] This high prevalence of cardiovascular disease (CVD) events leads to a significant impact on patient quality of life and healthcare expenditure.

Participation in comprehensive, multidisciplinary cardiac rehabilitation (CR) programmes as part of secondary prevention is recommended for patients with CVD and heart failure (HF) to improve outcomes.[3] In addition, multiple studies have demonstrated clinical benefits, possible cost-savings and cost-effectiveness of CR.[4–7] The aim of a CR programme is to improve the patient's physical, psychological, social, and work conditions via core components, including patient assessment, management and control of cardiovascular risk factor control, physical activity counselling, prescription of exercise training and optimizing guideline-directed medical therapy, dietary advice, smoking cessation, patient education, psychosocial counselling, and vocational reintegration.[8] Core components centre-based CR are routinely delivered during Phase 2 CR but could also be extended to Phase 3 CR programmes to support long-term adherence to lifestyle changes.[8] Indeed, secondary prevention is more a lifelong process where cardiac telerehabilitation (CTR) could provide opportunities to minimize pressure off the time-limited phases of CR.[9]

Despite the clear benefits of CR, recent data reveal that participation in CR is only around 30%–40% of eligible patients in Europe.[2] Important predictors for not participating are older age, unemployment, multiple comorbidities, female sex, and smoking. Other common barriers are lack of referral, misconceptions about the effectiveness of CR and practical barriers such as long distance to the CR centre, limitations in transport, and scheduling issues.[10] Furthermore, the EUROASPIRE surveys have demonstrated that not only the participation in CR is disappointingly low, but that many patients with a history of ASCVD do not meet the secondary prevention targets set by the European guidelines.[2]

In recent years, home-based CR, delivered by telerehabilitation, has been suggested as an alternative or adjunct to centre-based CR to increase access, adherence, and participation rates.[11] Telerehabilitation can include tele-coaching, social interaction, telemonitoring, e-learning, and addresses almost all CR core components.[11] Non-digital home-based cardiac rehabilitation (NDHBCR) programmes, which rely on manual or self-reported methods of intervention and monitoring, pose unique challenges. NDHBCR typically depends on patient self-reports or occasional follow-ups, which lack the objectivity and reliability

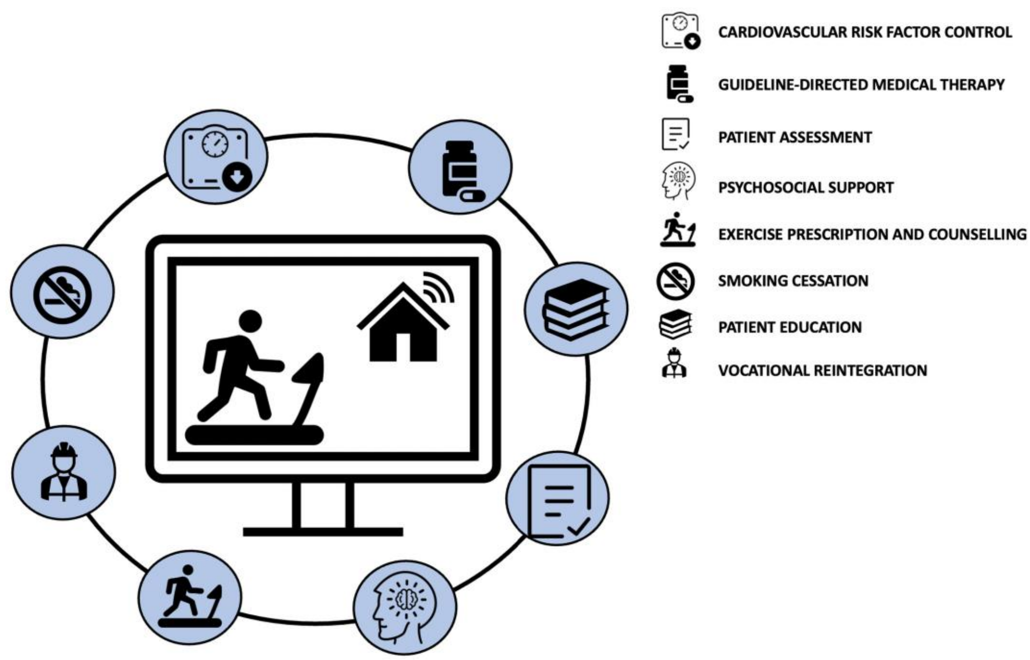


Figure 1 Core components of cardiac telerehabilitation

required to evaluate metrics such as exercise adherence, intensity, and physiological improvement. Without monitoring or feedback mechanisms, these programmes are unable to ensure consistency or scalability, and their effectiveness varies widely across patients and settings.

Non-digital programmes, while sometimes the only available option in low-resource settings, face intrinsic limitations that prevent their inclusion in discussions about quality indicators and standards for telerehabilitation. As such, this paper prioritizes interventions supported by digital monitoring tools.

In addition to improving the uptake of CR directly after a cardiac event, CTR provides the opportunity to extend the delivery of structured secondary prevention programmes well beyond the 24–36 sessions of traditional CR.[12]

During the past decade, initial evidence suggests that CTR may be an effective replacement or complementary strategy to centre-based CR in terms of improving aerobic capacity, cardiac risk factors, and health-related quality of life.[13] As such, telerehabilitation may be considered to increase patient participation in CR and long-term adherence to healthy behaviours, according to the ESC Prevention in Cardiovascular Disease guidelines.[3] However, its implementation in healthcare systems has remained disappointingly low. Low levels of digital health literacy in patients with CVD and healthcare professionals and the lack of cost-effectiveness studies are often reported as key barriers for implementation in real-world settings.[14,15] Other key barriers are the lack of appropriate and well-assessed mobile health devices for CTR and the integration with electronic patient files. Recently, criteria were proposed to assist healthcare professionals in the evaluation of appropriate mHealth solutions.[16]

To foster the implementation of CTR in Europe, the European Association of Preventive Cardiology (EAPC) of the ESC has defined the presence of CTR programmes as one of the optimal criteria for centres requesting accreditation for secondary prevention and CR. However, the contemporary EAPC position statement on standardization and quality improvement of secondary prevention through cardiovascular rehabilitation programmes in Europe does not include guidance on minimal and optimal requirements for CTR.[12] This paper aims to summarize the existing evidence and gaps of knowledge in this field which will be used together with an expert panel to propose novel minimal and optimal requirements.

Definition of cardiac telerehabilitation

The definition of CTR is the delivery of cardiac rehabilitation services using digital health technologies and telecommunications to support patients in their homes. It encompasses a range of interventions, including all CR core components, provided through video conferencing, remote monitoring, mobile applications, and other digital platforms to enhance access, convenience, and continuity of care. The different core components are presented in *Figure 1*. The choice of digital tools used could be adapted to the local context, technical infrastructure, and patients' needs and preferences. No specific tools or protocols will be advised due to the differences in availability across countries and due to the rapid technological advances. Furthermore, there is no randomized controlled trial (RCT) investigating the effectiveness of different CTR tools in one study. We propose to use well-validated digital tools for safety in effectiveness. The lack of a specific protocol for CTR in this paper could be explained by the fact that there is significant heterogeneity in the organization of centre-based CR in different countries. The provision of a uniform CTR protocol without attention to the local context could halt implementation. Therefore, it is important that CTR programmes are developed by co-creation and are adapted to the local context with the inclusion of all core components.

One of the main goals of CTR is to overcome the barriers to attendance such as scheduling and transport issues.[10] CTR could also allow the provision of long-term secondary prevention programmes with the use of digital devices and companions such as shared decision-making applications.[17]

Furthermore, CTR could facilitate shared decision-making by meeting the needs and preferences of patients and healthcare professionals potentially resulting in an improvement in programme enrolment, adherence, and effectivity.[17]

The most well-established indications for CTR, supported by clinical research, include percutaneous coronary intervention, myocardial infarction, coronary artery bypass grafting, and HF.[8] Other indications such as atrial fibrillation ablation, pacemaker, and implantable cardiac defibrillator implantation, as well as other cardiovascular and even non-cardiovascular conditions, could potentially be managed with telerehabilitation. However, these emerging indications require further investigation to establish efficacy and safety before they can be routinely included in standard practice. The current evidence suggests starting with CTR at the same time centre-based CR would start with the same duration as centre-based CR.[18–20] CTR has the potential to provide long-term secondary prevention monitoring; however, there is only limited evidence for now.

Two models of CTR exist:

(1) Fully remote CTR
(2) Hybrid CTR

In the fully remote CTR model, centre-based CR is completely replaced by CTR. There are no centre-based CR sessions for participating patients. However, patient assessment, risk factor management, and pre-exercise screening are advised to be organized in an outpatient setting. A content-selection hybrid model is defined as a programme where several core components are delivered in the CR centre, while others are delivered remotely. The choice of which core components are remotely delivered could be adapted after shared decision-making. Moreover, the choice can change over time, based on the patient's progress and modified needs. In a full-content hybrid CTR model, all core components are either delivered remotely or at the CR centre. This could be done in an add-on model, where patients engage in a combination of remote and centre-based sessions, or as a transition model, where patients start with centre-based CR sessions for several weeks and then switch to a CTR programme.

Furthermore, two methods of remote CTR exist: synchronous and asynchronous CTR. Synchronous CTR consists of real-time remote interaction between a patient and a healthcare professional when working on one of the core components. An example of synchronous CTR is a video connection during exercise between a physiotherapist and a patient. The synchronous monitoring system may include a specialized remote device for tele-ECG monitoring and supervised exercise training, including blood pressure measuring and weighing machine, and data transmission set via a mobile phone.[18]

This has the advantage of personalized follow-up and better individualization; however, it may be associated with a higher workload for healthcare professionals and, consequently, higher costs.

In asynchronous CTR, there is no real-time interaction or follow-up between the patients and the healthcare providers. Patient data are sent to the CR centre and will be monitored intermittently at fixed moments or if alerts occur. This way of remote monitoring focuses more on self-management with intermittent feedback. It is presumed that it may be less labour-extensive and less expensive, providing the opportunity to manage larger groups of patients simultaneously. It could also increase patients' autonomy by focusing on self-management and improving the availability of CR services outside the traditional working hours. However, most studies using this approach focused only on stable low-risk patients.[19,20]

A mixed approach combining synchronous and asynchronous CTR is possible. An example of a mixed approach may be a combination of online meetings with a dietician and sending pictures of meals, later reviewed by the dietician. Lastly, there is the possibility of using real-time computer-generated communications in asynchronous CTR automatically triggered by device measurements.

Evidence on cardiac telerehabilitation

An overview of the available evidence regarding CTR interventions was performed by a pragmatic narrative umbrella review.[21] A search for systematic reviews and meta-analyses published in the last decade on the PubMed and Cochrane database was performed in November 2023 using the search terms (cardiac/cardiological) telerehabilitation combined with 'cardiovascular disease', 'acute coronary syndrome', 'myocardial infarction', 'coronary heart disease', and 'heart failure', respectively. After the removal of duplicates, 36 remaining papers were reviewed independently by four researchers for eligibility in full text. Seventeen publications were excluded by consensus due to non-defined or unsuitable population investigated in the review studies ($n = 8$), type or timepoint of interventions (e.g. educational programmes without exercise, peri-operative intervention; $n = 6$), design aspects (review of qualitative studies, no control group defined; $n = 2$), and publication before 2013 ($n = 1$). Pearl growing method was used to identify 10 additional papers. The key characteristics of 28 included systematic reviews were extracted regarding population, key interventions, pre-defined outcome measures, and main results, as provided in Appendix Table A1.

The umbrella review revealed first a major point of concern regarding the quality of the included systematic reviews and meta-analysis. Many of the meta-analyses showed important heterogeneity between the included studies in patient population, duration of intervention, used technology, and outcomes. Moreover, multiple meta-analyses combined both centre-based CR and no intervention or usual care as a control group. This makes generalization of the results of the included meta-analyses difficult.

Furthermore, none of the interventions included all core components and therefore fulfilled the definition of CTR.

Four reviews[22–25] investigated the effectiveness of CTR in patients with HF. Two studies demonstrated a superior effect of CTR in terms of exercise capacity and QoL.[24,25] However, the control group consisted both of usual care (without CR components) and centre-based CR. The study by Gao *et al.*[25] differentiated the comparison between CTR vs usual care and CTR vs centre-based CR and concluded that CTR was non-inferior in terms of QoL and exercise capacity in comparison with centre-based CR. Still, large heterogeneity was observed in the intervention (duration, technology used, etc.). The study of Gao *et al.*[25] reported a reduction rehospitalization compared with usual care, but no significant reduction compared with centre-based CR. Importantly, only study was included that reported on the comparison of readmission rates between CTR and centre-based CR.

Recent literature such as the EXIT-HF trial[49] and a network meta-analysis by Tegegne *et al.*[50] showed a similar message. The EXIT-HF was an RCT including 120 patients comparing CTR for patients with HFrEF and HFpEF with centre-based CR. The study demonstrated the non-inferiority of CTR in terms of exercise capacity and QoL. Tegegne *et al.*[50] performed a large network meta-analysis including 18 670 patients in 132 randomized controlled trials investigated the relative effectiveness of different exercise-based CR delivery modes for HF patients. Ten studies researched the effectiveness of CTR. This meta-analysis showed that CTR was associated with improvements in exercise capacity, however, no improvement in HF-related hospitalization or mortality risk. An important comment is the fact that 7 out of 10 trials compared CTR with usual care.

In conclusion, current evidence seems to demonstrate that CTR is a feasible, safe, and non-inferior intervention to centre-based CR for HF patients; however, the large heterogeneity must be considered. More robust data is still needed.

In total, 21 reviews[26–45] investigated the effectiveness of CTR in cardiovascular patients with indications for CR. The included patient populations were very heterogeneous and not always defined. Many meta-analyses had significant limitations such as no definition of CTR intervention, comparator arm consisting of both CR and no intervention or inclusion of CTR interventions solely consisting of telephone calls. Seven studies evaluated the effectiveness and safety of CTR in comparison with centre-based CR.[11,26,28,35,39,41] Six[11,26,28,39,41] out of seven meta-analyses showed no significant differences in exercise capacity between CTR and centre-based CR. One meta-analysis demonstrated a significant improvement in peak VO_2 in the CTR group; however, only four studies were included.[35] The meta-analysis of Murphy *et al.*[39] showed a significant difference in 6-min walking test distance; however, the mean difference is not clinically relevant. In general, current evidence seems to show that CTR for patients with CR indication results in similar improvements in exercise capacity compared with centre-based CR. A similar message was reported in a recent Cochrane review by McDonagh *et al.*[51] This review concluded that home-based CR interventions are similarly effective in improving clinical and health-related quality of life outcomes in patients after myocardial infarction, or revascularization, or with HF. However, only 4 trials out of 24 used TR.[51]

A recent umbrella review by Shi *et al.*[52] also demonstrated that CTR interventions could improve exercise capacity and medication adherence. An important sidenote again is the fact that multiple included meta-analyses had also control group consisting of centre-based CR and usual follow-up. Moreover, the umbrella review showed no difference in clinical endpoints.[52]

Two meta-analyses focused solely on hybrid CTR. One study compared to hospital-based and centre-based CR and showed no significant differences with CTR in QoL or exercise capacity.[32,33] The meta-analysis by Yang *et al.*[33] revealed improved exercise capacity and functional capacity in the CTR group; however, it was compared to a control group consisting both of centre-based CR and no intervention at all.

In conclusion, CTR seems non-inferior to centre-based CR in improving exercise capacity and QoL. However, current evidence has multiple limitations mostly due to the large heterogeneity among the study protocols and sample characteristics, determining a high variability in the results. Another limitation is the limited number of meta-analyses. Moreover, some studies addressing CVD telerehabilitation also included neurological or pneumological diseases. Another limitation concerns poor reporting and uncertain definition of CTR interventions, specific methods, pre-defined outcome measures, and study endpoints. This highlights the need for well-executed randomized controlled trials to further determine the effectiveness of CTR but also determine differences in effectiveness between different CTR models. Further data are also needed to determine whether the short-term effects of CTR can be confirmed in the longer-term.

Advised standards of cardiac telerehabilitation

Core components and minimal/optimal standards are well-established in conventional CR. To propose new core components and standards for CTR, the following methodology was employed.

The core components of CR were derived from Ambrosetti *et al.*[8] The minimal and optimal standards for CR were sourced from Abreu *et al.*[12] All statements for conventional CR were compiled. These statements were then reformulated and adapted to the context of CTR. A panel of Experts reviewed, approved, and supplemented these statements with additional aspects specific to CTR, which are lacking in conventional CR.

To achieve consensus on the statements, a modified Delphi methodology was utilized.[53] All statements were compiled and administered via Qualtrics software. A panel of 16 experts rated each statement on two criteria validity and feasibility. Validity and feasibility were defined following the definitions provided by Aktaa *et al.*[53] More information about the methodology can be found in the Appendix.

Initially, 138 statements were listed. Following the first Delphi round, 11 new statements were added. The total number of rated statements was thus 149. In the first Delphi round, 99 statements were included, 23 were inconclusive and/or reformulated, and 16 were excluded.

In the second Delphi round, 34 statements were rated; 18 statements were included, 16 excluded, resulting in 117 accepted statements.

Full results of Delphi rounds are provided in *Tables 1 and 2*. Additional standards are provided in the Appendix *Table A2*.

Core components

(1) Patient assessment

The consensus statements highlight the need for an initial comprehensive on-site physical exam, with parts of the assessment conducted remotely. A comprehensive physical exam with ECG, exercise test for risk stratification and exercise prescription and, if necessary, echocardiography before the start of a CTR programme is advised to be performed on-site.

Basic information and physical activity levels should be monitored digitally using wearable devices, considered superior to questionnaires. During rehabilitation, remote symptom assessment, detailed digital questionnaires, and consistent monitoring of adherence are advised.

2) Physical activity counselling

The consensus statements emphasize using wearable devices to track step count, moderate-to-vigorous physical activity (MVPA), and sedentary time. Counselling should be conducted via telephone, can be supported by automated smartphone feedback, and may involve personalized sessions with trained exercise specialists. Validated wearable devices are advised for accurate physical activity monitoring.

3) Exercise training

The consensus statements recommend extensive in-centre risk assessment and an exercise test before the start of a CTR programme.

Table 1 Proposed core components and CTR standards

1) Core components

Patient assessment

- While parts of the physical assessment can be performed remotely (video call, remote ECG using smartwatch, or other technology), a **full physical exam** with ECG and, if necessary, echocardiography before the start of a CTR programme is recommended to be performed on-site.

The following components have a high potential for translation to remote/digital assessment:

- Basic information such as educational level, social background, diet, and even routine symptoms can be assessed through (ideally validated) **questionnaires** digitally (e.g. through the patient's smartphone or a web-based form).
- Physical activity level is best assessed using a **wearable device**, which offers better insights compared to questionnaires.
- Exercise capacity and physical activity level: while cardiopulmonary exercise testing remains the gold standard as pre-exercise screening, there is a growing role for complementary **continuous physical activity monitoring** and intermittent submaximal exercise testing (e.g. remote 6-min walking test).
- The **first** baseline full patient assessment should be ideally **on-site**.

Patient assessment during rehabilitation

- During the rehabilitation programme, the **symptom** assessment can be performed remotely via **teleconsultation**.
- During the rehabilitation programme, the use of **digital questionnaires** to gather detailed patient history and symptomatology is desirable.
- **Adherence** to the telerehabilitation should be consistently **monitored**.

Physical activity counselling

The following metrics as measured by a wearable device/accelerometer can be used:

- Step count.
- Minutes of moderate-to-vigorous physical activity (MVPA) as measured/estimated by heart rate assessment and/or step intensity.
- Sedentary time.

Physical activity counselling can be performed in-person or remotely ideally through direct contact with a trained exercise specialist:

- Through telephone counselling.
- Can be supported by automated feedback e.g. through a smartphone application.
- Validated wearable devices need to be advised for physical activity counselling.
- Personalized counselling sessions via video calls or telephone consultation with trained exercise specialists should be provided.

Exercise training

- During **initial phases**, exercise training is preferably delivered through **real-time monitoring** to verify individual responses, tolerably, and clinical stability.
- A possible advantage of CTR is the addition of parameters that not only monitor **aerobic training** (with a minimum goal of three times per week) but can also measure **physical activity** and **sedentary time** on non-training days.
- If the programme can **start** with a period of **on-site training** that can help in evaluating and adapting individual responses and prescription (hybrid).

Diet/nutritional counselling

- **Fully remote** follow-up is achievable in nutritional follow-up as teleconsultations are in theory equally valuable as physical consultations.

Digital health technology can be used for supporting remote dietary follow-up in the following ways:

- Assessment of baseline daily caloric intake through **diary-based smartphone applications** or web-based platforms.
- Adaptation of caloric intake as well as diet composition through diary-based smartphone applications or web-based platforms.
- Nutritional **education** through validated health websites and smartphone applications.
- Specific dietary pattern can be assessed through **validated questionnaires** assessing e.g. Mediterranean diet compliance.
- Teleconsult for nutritional evaluation and advise is a minimum criterion.
- Referral to web-based or app-based library of digital resources on dietary goals and attainment methods, including the salt, lipid, and water content of common foods.

Continued

Table 1 ***Continued***

1) Core components

Weight control management

Baseline assessment can be performed on-site in-person or can be achieved remotely through insertion of the following parameters:

- Weight (as measured by the same weighing scale throughout the prevention trajectory).
- Analysis of nutritional habits through questionnaires.
- Calories intake through diary-based applications or web-based platforms.
- Physical activity through wearable devices and/or questionnaire-based.
- Weight reduction can be prescribed and followed-up through patient self-measurement and reporting.
- Nutritional education through validated health websites and smartphone applications can be performed.

Lipid management

Opportunities for digital health:

- **Patient education** about hypercholesterolaemia aetiology, lifestyle involvement and pharmacological therapies through validated websites or smartphone applications.
- **Educational videos** for cholesterol risks and management should be included in the telerehabilitation programme.

Blood pressure management

- A **baseline** resting assessment of multiple blood pressure values should be available for every patient, **ideally** measured in a **home-based** setting in resting conditions.
- For hypertension monitoring **remote blood pressure** measurement and registration by the patient at home is recommended with attainment of the recommended blood pressure goals during the CTR programme.
- Home-based measurement by patient should be a minimal standard for cardiac telerehabilitation.
- Home-based measurement by patient with connected devices, ideally incorporated in a cardiac telerehabilitation module should be an optimal standard.

Other opportunities for digital health include

- **Medication decision support** for caregivers can be used for blood pressure monitoring in telerehabilitation.
- **Medication adherence monitoring** tools can be used for blood pressure monitoring in telerehabilitation.

Smoking cessation

Opportunities for digital health:

- Diary-based smartphone applications (or web-based platforms).
- Education through validated websites and smartphone applications.
- Follow-up by a human expert is recommended but could be performed fully remotely.
- **Digital health interventions** may not replace but should **support pharmacological therapies.**
- **Teleconsultation** with psychologists is an important part of remote smoking cessation.
- Use **digital questionnaires** to assess smoking status, including the amount and duration of smoking.

Psychosocial management

Opportunities for digital health consist of:

- After an initial, on-site, intake interview with the patient, further **follow-up** could be organized **remotely**.
- Follow-up can be performed supported by automated tools such as **validated questionnaires** on pre-specified intervals (HeartQoL, HADS, GAD).
- A **two-step evaluation approach** should be used: initial **single-item questions** about distinct psychosocial risk factors followed by **standardized questionnaires** (e.g. HeartQoL, KCCQ for disease-specific QoL, HADS or GAD7, PHQ9 for anxiety and depression).
- The provision of individualized **teleconsults**, sessions of relaxation, meditation, and yoga can be part of optimal standards for cardiac telerehabilitation.
- Digital resources and tools to teach and support **self-help strategies** and effective **social support** acquisition should be provided.

Table 2 Proposed digital health-specific CTR standards

Digital health-specific standards for cardiac telerehabilitation
Minimal
• Privacy and data protection: all data are processed on **data-secure platforms** either for handling of the electronical medical record or of telerehabilitation data.
• Concerning data privacy and data ownership, **national data privacy and ownership legal regulations** must be followed.
Optimal
• **Shared decision-making**, which involves collaboratively setting goals between the patient and healthcare provider, should be used especially in cardiac telerehabilitation to ensure personalization of the treatment.
• **Cardiac telerehabilitation** should be **implemented as an alternative** to centre-based cardiac rehabilitation to leverage uptake and adherence.
• If device-based physical activity monitoring is implemented, **loan devices** (i.e. devices offered to patients by the telerehabilitation programme for the duration of the programme) would be needed to maximize equity of access.
• Data should be collected to **one central platform** or medical record system on which personnel access the data.
• A **central dashboard** allows for easy follow-up of all patients currently in cardiac rehabilitation or telerehabilitation.
• A **relapse prevention system** is defined as a system patients are monitored in the long-term phase and are contacted in the case of nonadherence to the intervention or reduced exercise or physical activity volumes. Statement: A relapse prevention system should be part of the telerehabilitation system and programme.
• **Structured data capture system** in which all patient assessment, training and telemonitoring data is stored in a structured format to easily allow quality control and research.
• A **long-term follow-up telerehabilitation programme** is conducted in which telerehabilitation is continued until a saturation point is reached. This point is defined as the point on which behaviour change is considered permanent. The patient can keep measuring their own data while receiving automated feedback, but there is no more need for human support.
• A **dedicated digital platform** should be available for parameter monitoring, personalized goal setting, and patient motivation
• Data obtained from **measurements** (e.g. wearable devices, smartphones, medical equipment) is needed as self-reported data is insufficiently accurate.

In high-risk patients, real-time monitoring during the initial exercise training phases to control individual responses and clinical stability is advised. A potential benefit of CTR is the ability to track aerobic training, heart rate response, physical activity level, and sedentary time. Starting with on-site assessment can help to evaluate individual responses and tailor prescriptions.

4) Diet/nutritional counselling

The consensus statements suggest that nutritional follow-up can be effectively conducted remotely via teleconsultations. Baseline caloric intake and diet composition should be tracked and adapted using smartphone or web-based applications. Nutritional education can be provided through validated health websites and apps, while specific dietary patterns assessed with validated questionnaires. Teleconsultations for nutritional evaluation are advised, complemented by digital resources on dietary goals and food content.

5) Weight control management

The consensus statements emphasize consistent weight monitoring using the same scale, and the use of automatic weight transmission can be considered. Nutrition habits can be analysed through questionnaires, tracking calorie intake with diary-based apps or web platforms. Nutritional education should utilize validated health websites and smartphone apps. Physical activity should be monitored using wearable devices or questionnaires. Weight reduction strategies can involve patient self-measurement and reporting.

6) Lipid management

The consensus statements emphasize patient education on hypercholesterolaemia, covering its causes, lifestyle interventions, and pharmacological treatments through validated websites or smartphone applications. The telerehabilitation programme could include educational videos focusing on associated risks and management. These elements are advised for comprehensive patient understanding and management of hypercholesterolaemia. Last, repeat blood tests should be planned during CTR to ensure optimal guideline-based medical therapy.

7) Blood pressure management

Key points for blood pressure management include baseline resting blood pressure assessments ideally in home settings, remote blood pressure monitoring by patients to achieve goals during CTR and integrating connected devices for optimal monitoring. The use of automatic transmission can be considered.

The frequency of measurements should be according to the ESC Prevention guidelines[3] at least three consecutive days (ideally 6–7 days) with readings in the morning and evening. Tools for medication decision support and adherence are advised for effective hypertension management in telerehabilitation.

8) Smoking cessation

Key strategies for smoking cessation include using diary-based smartphone apps or web platforms, educating patients through validated websites and smartphone apps, and recommending remote follow-up by experts. Digital health interventions should support, not replace a multidisciplinary treatment approach, including pharmacological therapies. Teleconsultations with psychologists play a crucial role in remote smoking cessation, supported by digital questionnaires to assess smoking status.

9) Psychosocial management

Psychosocial management in CTR involves initial on-site interviews followed by remote follow-up using validated questionnaires. It includes a two-step evaluation process as mentioned by Ambrosetti *et al*.[8] initial single-item questions on psychosocial risk factors, then standardized questionnaires measuring anxiety and depression. Based on the results of the questionnaires, the intervention can include personalized teleconsultations, relaxation techniques, and digital tools for self-help and social support.

10) Digital health-specific standards

Minimal digital health standards in telerehabilitation require secure data processing and adherence to national privacy regulations. Optimal standards prioritize shared decision-making, position CTR as a primary option to boost adherence, provide loaned monitoring devices for equitable access, ensure centralized data management, integrate relapse prevention measures, maintain structured data capture for quality control and research, sustain long-term programmes until behaviour change is permanent, and employ dedicated platforms for effective education, monitoring, and motivation based on individual information and preferences.

Role of cardiac telerehabilitation in secondary prevention

The increasing interest in CTR primarily revolves around addressing the known barriers of current centre-based CR programme. Therefore, the goal of developing CTR programmes is not to replace centre-based CR but to offer an alternative or complement to current standard care.

Remote CTR programmes will benefit from a close interaction with centre-based programmes. This is evident in hybrid programmes, but also in full CTR programmes, where a connection to centre-based CR is important to maintain a human touch. This human connection seems especially necessary for baseline safety assessment, motivation, adherence, and feedback on educational progress. CTR encompasses more than just telemonitoring; some core components of CR, such as psychosocial management, may require occasional face-to-face interactions. The provision of remote programmes does not mean that some aspects of centre-based CR cannot be utilized. Hybrid programmes can be used to provide a programme that is adapted to the patients' preferences and needs, aiming to improve participation, adherence, and long-term outcomes.

There are both patient-level and system-level benefits to organizing CTR in a CR centre. The provision of CTR could help alleviate patient-related barriers such as limitations in transportation or time constraints, thereby potentially increasing the engagement of CR after an acute cardiac event.[10] Another patient-related barrier is the lack of personalization.[17] The digital component enables easier customization to meet patients' preferences and needs. For instance, content and support can be tailored to applicable risk factors, educational levels, or stages of change. In the future, further personalization could be achieved with the introduction of digital biomarkers for better phenotyping of the intervention and adopting the recommendations over time.

A recent systematic review suggests that CTR could lead to cost-savings in healthcare and might be a cost-effective alternative to centre-based CR.[46] Potential factors are the lower workload and lower demand for training space.[46] The introduction of algorithms could further alleviate the workload for health professionals, thereby potentially enhancing the cost-effectiveness of CTR. Therefore, increased focus could be allocated to long-term management. Currently, secondary prevention programmes[1] often conclude after Phase 2. However, research has shown that objectively measured physical activity declines to baseline levels after CR.[54] The use of web or mobile applications and wearable devices such as heart rate monitors and accelerometers could be useful tools to monitor and motivate patients to adhere lifelong to the lessons learned in CR. A study by Lunde[55] *et al.* demonstrated that individualized follow-up for 1 year with an app significantly improved VO_2 peak, exercise performance and exercise habits, as well as self-perceived goal achievement. However, only a limited number of studies have investigated the long-term effectiveness of CTR, and findings have been mixed.[19,56] A recent trial has shown disappointing results in preventing relapses in physical inactivity compared to extended centre-based CR programmes.[56]

The introduction of lifelong secondary prevention programmes could be halted due to the growing shortage of healthcare workers. Therefore, the use of digital biomarkers in combination with chatbots and relational artificial intelligence could reduce the workload of lifelong programmes.

As the duration of CTR extends, adherence to the programme often declines. Consequently, prioritizing persuasive design techniques such as gamification and co-creation becomes imperative to foster long-term patient engagement. Integration of these interventions into patients' daily routines and home environments could help ensure long-term uptake and adherence.

It is important to be aware of potential risks of the introduction of CTR. The use of digital health comes with a risk of a digital divide. Patients with low digital health skills will not be able to get the same care. Especially, age and low socioeconomic status are linked with low digital health literacy.[57] Moreover, providing digital health to patients with low literacy levels or skills leads to low usage and adherence which diminishes the positive effects.[58] A recent paper developed a questionnaire to assess the patient's readiness to use digital health.[59] Based on this questionnaire, patients can be grouped as good CTR candidates vs patients needing additional teaching before starting digital health interventions. This highlights again the importance of co-creating and developing digital tools for different levels of digital health skills and literacy. Recently, Living Labs interventions are gaining interest, as they could be used for co-creation and shared decision-making, including patients, healthcare professionals, and industry.

While clinical indications for CTR parallel those of centre-based CR, a comprehensive risk assessment is imperative before permitting moderate to high-intensity physical activities at home. When selecting the optimal patients for CTR, it is crucial to consider limitations such as the lack of ECG monitoring and the potential for physical exercise overload. To date, there is only limited evidence about the use of CTR in high-risk populations. As clinical indications for CTR parallel those of centre-based CR, the content of the different core components should be adapted to the specific cardiovascular disease both in CR and CTR.

Lastly, CTR will not solve all barriers to CR participation and adherence. Studies have indicated that approximately 30% of eligible patients not participating in-centre-based CR would participate in CTR.[14,60] Therefore, it remains important to use patient forums, medical associations, and innovative approaches to adapt CR programmes[1] to engage as many patients as possible.

Technical infrastructure and data security

A robust digital infrastructure is essential for the success of telerehabilitation programmes, as it enables the collection and monitoring of accurate, actionable health data in real time.[61] Tools such as wearable devices, mobile health applications, and telemonitoring platforms play a pivotal role in capturing key metrics like physical activity, heart rate, and blood pressure. Integrating such systems into a secure and scalable infrastructure ensures consistent data collection and analysis across diverse patient populations, thereby enhancing the reliability and effectiveness of telerehabilitation services.

However, current wearable technologies face significant limitations that affect their medical validation and acceptance in clinical practice. While many wearables are widely used for fitness tracking, their accuracy in measuring clinical-grade parameters remains inconsistent. For example, wearables often lack rigorous validation against medical standards. Additionally, variability in device algorithms and sensor sensitivity can lead to data discrepancies, undermining their reliability for medical use. Therefore, it is important to use well validated and are qualified as medical products. A recent paper by Caiani *et al*.[16] has proposed criteria with which health professionals could evaluate mHealth solutions.

One of the core principles of the CTR should be empowering patients with control over their personal health data. This principle aligns closely with the General Data Protection Regulation (GDPR), which mandates that individuals must have the ability to make informed decisions about how their data is accessed, used, and shared.[62] For CTR platforms, integrating comprehensive consent management systems is essential. These systems should enable patients to grant, revoke, or modify access to their health data with ease, ensuring transparency and control. Furthermore, to protect patient privacy and comply with GDPR, telerehabilitation platforms should adopt data minimization practices, ensuring that only the necessary data required for a specific purpose is collected and processed. This principle reduces the risk of misuse or unauthorized access to sensitive information. Additionally, platforms should employ advanced pseudonymization and anonymization techniques to safeguard patient data while enabling its secondary use for research, public health, and innovation.[63]

Conclusion and future directions

The increasing interest of CTR in recent years is addressing the well-known barriers of centre-based CR in terms of attendance and long-term management of secondary prevention. The digital component may also enable easier customization to meet patients' preferences and needs.

This document highlights that current evidence on the effectiveness and safety of CTR as adjunct or alternative to centre-based CR is promising, but there are still conflicting results, mostly due to the small and limited number of studies, methodological considerations, and lack of long-term follow-up. To achieve future high-quality evidence and large-scale implementation of CTR in clinical practice, some considerations need to be addressed.

CTR interventions and modes of delivery are heterogeneous and poorly defined in most of the existing studies, which limits interpretation and clinical implementation. To improve the design and reporting of future studies in this field, this document aims to provide shared definitions for CTR programmes. Clear definitions facilitate future comparison of different CTR models, including CTR only or hybrid programmes[1] with synchronous or asynchronous monitoring. Comparing different CTR settings and approaches is important to determine which procedures may best meet the needs of specific sub-populations of patients.

The content of different core components is different across CTR studies and often not very well stated in the literature. As CTR is the remote provision of the core components of comprehensive Phase 2 CR, this document provides shared definitions on minimal and optimal requirements of CTR core components, to reduce the heterogeneity in future studies.

In the current digital era, it is still important to remember that CTR programmes[1] will benefit from close interaction with centre-based programmes.[1] Additional research needs to address how the optimal interaction between centre-based CR and CTR should be conducted and whether the delivery of CTR is equally effective for all core components. Additionally, extending the current research focus of Phase 2 CR to include also Phase 1 CR to enable early patient empowerment and Phase 3 CR to improve long-term engagement to lifestyle changes would be of large interest. Furthermore, it is important to ensure that all patients can use these interventions. Potential patient-related barriers could be a lack of internet access, no access to technology (e.g. high cost), or low digital skills and digital literacy.[10,64] During the development of CTR interventions, focus is needed on these barriers in order to prevent the creation of a digital divide. Focus on an inclusive approach with co-creation with patients, educational initiatives and the provision of a device rental service could be solutions to reduce the digital divide as much as possible.

Home-based CR without any digital support could be an alternative option for these patients. However, the lack of monitoring is a serious limitation of this approach.

Most CTR studies are small, randomized control trials (RCTs) with strict inclusion and exclusion criteria, limiting the generalizability of study results in clinical practice. The design of large-scale pragmatic clinical studies including real-world patients is advised and will improve future implementation. This could include registry-based RCTs. An advantage of designing studies to include a broad representation of patient groups is that there could be an increased focus on health equity. In the future design of CTR studies, it is important to consider historically underrepresented groups of patients, such as women, elderly, those with lower socioeconomic status, diverse ethnicity or educational attainment, and individuals with disabilities.[65] Understanding patient acceptance and usability of CTR is crucial for a successful implementation into clinical practice. Co-designing CTR with patients is highly advised to meet end users' needs which may enhance usability and long-term engagement. Especially in a complex intervention such CTR, more research is needed on how to implement these interventions. It is well known that older age is a barrier for participation in digital health interventions and is linked with lower adherence and effectiveness.[55] Many cardiovascular patients are elderly, so it is important to adapt the interventions to their needs and preferences. Hybrid approaches could be an option for those in need for more human connection.

To improve quality and standardization of telerehabilitation, a Delphi procedure was performed to establish the advised requirements for a telerehabilitation intervention. These proposed standards could be used in quality control and could form the basis for quality indicators in the future.

In summary, CTR is an established part of the contemporary standard cardiovascular patient care with even a greater potential for a better utilization in the future. However, the goal of developing CTR programmes is not to replace centre-based CR, but rather to complement current standard of care and to provide a long-term secondary prevention care pathway to a broadest possible population. To increase implementation in clinical practice, shared decision-making is key to success, providing standardized CTR programmes that are adapted to the patients' preferences and needs. To improve quality and standardization of telerehabilitation, a Delphi procedure was performed to establish the advised requirements for a telerehabilitation intervention. These proposed standards are meant to build further on with further research and implementation and are a next step towards better and more widely implemented patient care.

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Data Availability

No data were generated or analysed for or in support of this paper.

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Appendix

Methodology Delphi procedure

In the first rating round, each statement was scored by each panellist on a 9-point ordinal scale for both validity and feasibility, where 1 denoted 'not valid or feasible' and 9 denoted 'very valid or feasible'. For each statement, the median validity, median feasibility, and mean absolute deviations from the median scores were calculated to assess the central tendency and dispersion of the panellists' ratings for both validity and feasibility.

After the first voting round, the candidate statements were categorized into three groups:

Included: Statements with high median ratings (≥7 for validity and ≥4 for feasibility) and minimal interrater dispersion scores (<1.5 for both validity and feasibility).

Inconclusive: Statements with high median ratings (≥7 for validity and ≥4 for feasibility) but high interrater dispersion scores (≥1.5 for either validity or feasibility).

Excluded: Statements with low median ratings (<7 for validity or <4 for feasibility) or high interrater dispersion scores for both validity and feasibility (≥1.5 for both).

During the first Delphi round, open comments were allowed in each section of the questionnaire. Based on these comments, 7 statements were reformulated, and 11 new statements were added.

A second Delphi round was conducted in which all 16 panellists re-evaluated the inconclusive and newly added statements. In this round, no open comments were permitted. Statements were then categorized as either included (based on the same criteria as previously mentioned) or excluded if they did not meet the inclusion criteria.

Table A1 Evidence on Cardiac Telerehabilitation: Systematic Reviews and Meta-Analyses of the last decade

Paper	Focus	Intervention	Control group	Population/ condition	Outcomes	Results	Comments
Heart failure							
Isernia *et al.* 2022[22]	Safety: yes; cost: no; effectiveness: yes	Home-based treatments delivered at distance by maintaining the communication between the clinician and the patient through technological facilities (platform, devices, etc.).	No intervention or CR.	Chronic HF and cardiomyopathies.	– PVO_2 – 6MWT – QoL – Adverse event – Adherence – Satisfaction	Eight studies with 782 patients. TR effective in improving PVO_2 compared with no intervention. TR non-inferior in improving 6MWT to CR. TR non-inferior in improving QoL compared with no intervention and CR. Adherence to TR intervention was 86%.	– Only one trial provided raw data to test the effect of TR on VO_2 compared with CR. – Only 85 patients included to determine non-inferiority in improving 6MWT (TR vs CR).
Cavalheiro *et al.* 2021[23]	Safety: yes; cost: yes; effectiveness: yes	Intervention including physical exercise prescription by a CR specialist, performed outside the hospital or the CR centre with some form of interaction between patients and medical team.	Usual care was defined as the standard multidisciplinary management programmes including regular follow-up planned appointments.	HF, age ≥18 years old. No restriction on LVEF.	– PVO_2 – 6MWT – QoL – HF hospitalizations – CVD mortality – Mental health – Cost-effectiveness	Seventeen studies with 2206 patients. 1081 patients undergoing standard of care (258 with CR and 803 without CR). TR superior in improving 6MWT and PVO_2 in comparison with control group. TR superior in improving QoL.	– Control group very heterogeneous with both CR and standard follow-up. –Some TR interventions consisted only of weekly telephone calls without monitoring.
Cordeiro *et al.* 2022[24]	Safety: no; effectiveness: yes; cost: no	TR, not specifically defined.	Regular follow-up, outpatient rehabilitation, centre-based CR programme.	HF patients. Adults.	– Quality of life (SF-36, MLHFQ, EQ-5D)	Five studies with 505 patients. TR was effective in improving QoL.	– Only 85 patients in control group received CR. – No definition of TR in inclusion criteria. – One trial included patients with combined HF and COPD.
Gao *et al.* 2023[25]	Safety: yes; cost: no, effectiveness: yes	Any web-based and/or mobile health remote	Supervised CR or routine standard	Patients over the age of 18 years with a	– LVEF – PVO_2	Sixteen studies, 4557 patients.	– No clear definition of TR

Continued

Table A1 Continued

Paper	Focus	Intervention	Control group	Population/ condition	Outcomes	Results	Comments
		application. Can be used alone or in combination with phone calls, text messages, and emails.	medical care in a hospital or outpatient setting.	medical diagnosis of HF, without sex restrictions.	– Heart rate – 6MWT – QoL – Readmission	TR improves heart rate, VO_2 peak, 6MWD, quality of life, and reduces readmission rates. No difference on LVEF when compared with usual care. No significant improvement when compared with centre-based CR.	intervention. – Separate analysis for usual care and centre-based CR. – Some studies included both CHD and HF patients.
Cardiovascular disease							
Chan *et al.* 2016[26]	Safety: no; cost: no; effectiveness: yes	TR with telemonitoring to assess signs, symptoms, and exercise parameters.	CR programme located in a hospital, clinic, or community centre in which healthcare practitioner supervision was delivered in-person.	Adult participants aged at least 18 years with physician-diagnosed COPD or CVD.	– PVO_2 – 6MWT – Exercise duration – Peak workload	Eight studies. No differences in exercise outcomes between CR and TR, except in exercise test duration (slightly favoured CR). No reported adverse events, hospitalizations, or mortality during telemonitored exercise. Health-related QoL improvements were not different between TR and CR groups.	– All studies published in 2014 or earlier. – One study included only COPD patients (not included in PVO_2 and 6MWT analysis).
Hwang *et al.* 2015[27]	Safety: yes; cost: yes; effectiveness: yes	Home-based TR as a core component (where at least 50% patient–provider contact was delivered by telephone, videoconference, or Web-based intervention) and encompassed at least two exercise sessions.	Not defined.	Patients >18 years of age with chronic cardiovascular or respiratory diseases.	– PVO_2 – 6MWT – QoL – Adherence – Healthcare utilization – Adverse events	11 studies, 908 patients. TR showed similar results in terms of exercise capacity and QoL. TR appears to have higher adherence rates.	– Systematic review only. – 6/11 studies published in 2003 or earlier. – Control group very heterogeneous with both CR and standard

Continued

Table A1 ***Continued***

Paper	Focus	Intervention	Control group	Population/ condition	Outcomes	Results	Comments
							follow-up. – Patients with respiratory disease included.
Jin Choo *et al.* 2022[28]	Safety: no; cost: no; effectiveness: yes	Exercise-based cardiac TR: delivery not defined.	Centre-based CR. No further definitions.	CHD	– PVO_2 – Peak heart rate – Peak respiratory exchange ratio – Systolic BP – Diastolic BP – Lipid profile – BMI, weight – QoL	Eight studies, 750 patients. Cardiac TR was non-inferior to centre-based rehabilitation. Only total cholesterol and mental quality of life obtained better outcomes after centre-based CR than after cardiac TR.	– Low number of included patients. – Heterogeneity in duration and use of technology in the TR group.
Stefanakis *et al.* 2022[29]	Safety: yes; cost: no; effectiveness: no	Telehealth intervention or hybrid exercise-based programme delivered by any following technology: telephone, computer, internet, or videoconferencing.	Not defined.	Not defined.	– Adverse or cardiac events – Exercise or intervention-related emergency calls – Hospitalization	Nine studies in total, one study with one serious adverse event: The risk of adverse events during home-based cardiac TR seems very low.	– Systematic review only. – Control group: both CR and no intervention. Large heterogeneity in the study population.
Nacarato *et al.* 2022[30]	Safety: no; cost: no; effectiveness: yes	Cardiovascular TR programme, not specified.	In-person cardiovascular CR or compared with a no intervention group.	Adults > 18 years old with any cardiopathy.	– PVO_2 – 6MWT – QoL	Twenty-six studies: 6MWT (9 studies), VO_2max (16 studies), QoL (21 studies). TR significant higher for all three outcomes.	– Control group: both CR and no intervention. – TR intervention not defined.
Ramachandran *et al.* 2022[11]	Safety: no; cost: no; effectiveness: yes	Any website-based and/or mobile health (mHealth) application used either as a standalone or supplemented with other delivery modes, such as text message, telephone or video calls,	Supervised CR or UC (standard medical care that does not include any supervised or structured exercise training).	Adults (≥18 years old) with CHD: myocardial infarction, acute coronary syndrome, angina pectoris, and patients after PCI or CABG.	– Symptom limiting exercise test – BP – Lipid profile – Blood glucose – BMI – QoL	Fourteen studies, 2869 patients in total. – TR vs usual care: significant improvement in 6MWT, physical activity and exercise habits, depression and	–Well-defined TR intervention. – Separate analysis for usual care and centre-based CR. – Only 354 patients included in the analysis between

Continued

Table A1 *Continued*

Paper	Focus	Intervention	Control group	Population/ condition	Outcomes	Results	Comments
		email, or telemonitoring to deliver Phase 2 CR or secondary prevention exclusively in the home setting.				QoL, and small significant effect on low-density lipoprotein. – TR vs centre-based CR: comparably effective (no analysis on QoL).	TR and centre-based CR.
Leslie *et al*. 2021[31]	Safety: no; cost: no; effectiveness: yes	Exercise intervention, delivered by a physiotherapist via videoconference.	Studies were not required to have a comparison group, but potential comparison groups included non-exercise interventions, in-person exercise interventions, or structured exercise interventions delivered via telephone.	Recently hospitalized adult medical patients (≥18 years of age).	– 6MWT – Muscle strength – QoL – Satisfaction	Three studies. 201 patients. TR comparably effective to in-person care. TR was also associated with high attendance rates and patient satisfaction.	– Systematic review only. – Only three studies, one study including only COPD patients.
Wu *et al*. 2018[32]	Safety: no; cost: no; effectiveness: yes	Hybrid cardiac TR. Not further defined.	Hospital-based or traditional CR.	Myocardial infarction, HF, cardiac surgery.	– QoL – METs – BP – Lipid profile – PVO_2	Six studies, 1195 patients. No significant differences in outcomes except for triglycerides (advantage for traditional CR).	– Only focus on hybrid TR. – No definition of hybrid TR.
Yang *et al*. 2023[33]	Safety: yes; cost: no; effectiveness: yes	Hybrid integrated TR. Studies were excluded if they only involved telemonitoring without rehabilitation exercise supervision.	Not defined.	CVD	– Readmission rate – Mortality – PVO_2 – QoL	Eight studies. 1578 patients. No difference in mortality and readmission rates. TR improved PVO_2 and 6MWT. No difference in QoL.	– Only focus on hybrid TR. – No definition of hybrid TR. – Control group: both CR and no intervention. – Only three studies reported data about

Continued

Table A1 *Continued*

Paper	Focus	Intervention	Control group	Population/ condition	Outcomes	Results	Comments
							mortality and readmission. – Only four studies reported data about QoL.
Zhong et al. 2023[34]	Safety: no; cost: no; effectiveness: yes	Home-based cardiac TR, technology: mobile phones, tablet computers, computers, television, or videoconferencing.	Usual care or active outpatient CR.	Patients hospitalized with CHD and treated with PCI.	– 6MWT – QoL – BP – Lipid profile – Anxiety and depression	Five studies. 595 patients TR shows significant improvement in 6MWT, systolic BP, triglycerides. No difference in QoL.	– Control group: both CR and no intervention. – Improvement in 6MWT; 2/3 studies compare with usual care.
Zhong et al. 2023[35]	Safety: yes; cost: no; effectiveness: yes; adherence: yes	Telecommunications technology combined with rehabilitation: rehabilitation delivery based on smartphone, virtual reality, wearable monitoring portable devices, internet interventions; remote monitoring and consultation, home-based.	Usual care or centre-based CR.	CVD [stable angina pectoris, acute coronary syndrome, myocardial infarction, postcoronary revascularization (i.e. PCI/CABG)].	– 6MWT – QoL – BP – Lipid profile – Anxiety and depression – BMI – Adverse events – Completion rate	Ten studies. 1417 patients. PVO_2 and QoL significant advantage for TR. No difference in BP, BMI, lipid profile.	– Separate analysis for usual care and centre-based CR. – Only four studies included in analysis PVO_2. – Analysis QoL: usual care and centre-based CR combined. – Comparison risk factors mainly in comparison with usual care.
Brors et al.[36]	Safety: no; cost: no; effectiveness: yes; adherence: yes	eHealth secondary prevention programme delivery via: (i) mHealth comprising mobile phone applications and/or text messages but excluding telephone calls; (ii) web-based technology; (iii) a combination of both.	Not defined.	CHD not further defined.	– Medication adherence – Exercise capacity – PA level – BP – BMI – QoL – Anxiety/depression	Twenty-four studies. 3654 patients. Only significant improvement in PA level, anxiety, QoL, and medication adherence.	– Systematic review only. – Heterogeneity in follow-up – Comparison with both usual care as CR.
Chong et al.[37]	Safety: no; cost: no; effectiveness: yes; adherence: yes	Technology-assisted interventions in CR.	Not defined.	Adults who have CHD.	– BP – Lipid profile – BMI	Nine studies, 1046 patients. No differences in any	– Not defined TR intervention.

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Table A1 *Continued*

Paper	Focus	Intervention	Control group	Population/ condition	Outcomes	Results	Comments
					– PVO2 – 6MWT – QoL – Anxiety/depression – Adherence	outcome but adherence (higher for TR).	
Devi *et al.*[38]	Safety: yes; cost: no; effectiveness: yes; adherence: yes	Internet-based interventions designed to promote a healthy lifestyle and medicines management and reduce cardiovascular risk in people with CHD.	Usual care or no intervention.	Adults with CHD, including those having experienced a myocardial infarction, a revascularization procedure, those with angina, or angiographically defined CHD.	– Medication adherence – Exercise capacity – PA level – BP – BMI – QoL – Anxiety/depression	Eleven studies. 1392 patients. Intervention group had higher exercise capacity and QoL. No other differences between groups.	– Control group: both CR and no intervention. – Meta-analysis performed in 2015.
Murphy *et al.*[39]	Safety: no; cost: no; effectiveness: yes; adherence: no	Publicly available smartphone-based CR programmes.	Traditional outpatient-based CR.	Coronary artery disease: post-acute coronary syndrome, undergoing percutaneous coronary intervention, and patients with a diagnosis of coronary artery disease, independent of intervention.	– 6MWT – BP – Lipid profile – BMI – Medication adherence – Clinical events – Smoking cessation – Glycemic control	Eight studies. 1120 patients. 6MWT was significantly greater in the smartphone group. There was no significant difference in BMI reduction, systolic blood pressure, or LDL cholesterol levels.	– No clinically significant difference in 6MWT.
Su *et al.*[40]	Safety: yes; cost: no; effectiveness: yes; adherence: no	Used a website or mobile application supplemented with other modes such as email, text message, phone call to deliver CR.	No interventions, waiting lists, usual care from services systems or active ingredients such as different levels of eHealth or centre-based CR to control group.	CHD	– PA – Daily steps – Dietary habits – Smoking – BP – Lipid profile – BMI – QoL – Rehospitalization – Mortality	Fourteen studies. 1783 patients. TR demonstrated outweighed benefits in improving dietary habits, LDL-C, and aerobic capacity as compared with any active control except centre-based CR. No benefits in smoking cessation, psychological health and	– Control group: both CR and no intervention.

Continued

Table A1 *Continued*

Paper	Focus	Intervention	Control group	Population/condition	Outcomes	Results	Comments
						mortality risk. Effective in reducing rehospitalization.	
Rawstorn *et al.*[41]	Safety: no; cost: no; effectiveness: yes; adherence: yes	TR interventions used ICT (e.g. telephone, mobile/smartphone, mobile application, portable computer, Internet, biosensors).	Usual care or non-telehealth centre-based CR.	Adults (≥18 years) with diagnosed CHD (atherosclerosis, angina pectoris, myocardial infarction, or coronary revascularization).	– PVO_2 – PA – Exercise adherence – BP – Lipid profile – BMI – Glycemic control – Clinical events	Eleven studies. 1189 patients. TR more effective in reducing diastolic BP and LDL cholesterol to centre-based CR. Similar results in exercise capacity and other CVD risk factors.	– Separate analysis for usual care and centre-based CR. – Published in 2016.
Gandhi *et al.*[42]	Safety: yes; cost: no; effectiveness: yes; adherence: yes	mHealth technology such as text messaging or mobile phone application.	Usual care (defined as all aspects of standard of care aside from the proposed mHealth intervention).	CVD including CHD, cerebrovascular disease, and peripheral vascular disease.	– Adherence to medication and/or follow-up appointments – BP – Lipid profile – BMI – Exercise – Smoking cessation – Clinical events	Twenty-seven studies. 5165 patients. Intervention group had higher exercise capacity and medication adherence. Intervention group had lower BMI and BP. mHealth group did not show a reduction in hospital readmission, with a small number of studies showing a reduction in angina and stroke recurrence. A trend towards lower observed mortality rate.	– Control group: both CR and no intervention. – 13 studies published in Chinese. – Most included studies used text messaging intervention.
Jin *et al.*[43]	Safety: yes; cost: no; effectiveness: yes; adherence: no	50% of patient–provider contact for risk factor modification (addressing multiple risk factors) advice being delivered by the telephone, Internet, videoconferencing, text messaging, or mobile apps. Telehealth	CR and/or usual care.	CHD.	– All-cause mortality – Rehospitalization – Lipid profile – BP – BMI – Smoking status – PA	Thirty studies. 7283 patients. TR was not significantly associated with lower mortality. TR was linked with lower rehospitalization compared with no intervention.	– Control group: both CR and no intervention.

Table A1 *Continued*

Paper	Focus	Intervention	Control group	Population/ condition	Outcomes	Results	Comments
		intervention could be delivered alone or as an adjunct to CR or usual care.					
Turan Kavradim *et al.*[44]	Safety: yes; cost: no; effectiveness: yes; adherence: no	Studies with telephone calls, text messages, and telemonitoring	Routine care, which means healthcare staff providing for patients' daily care in the usual and normal way.	Participants ≥18 years old and with CHD.	– Waist circumference – Medication adherence – Smoking cessation – BP – PA level – Lipid profile	Twenty-four studies. 6773 patients. TR had moderate significant effects in reducing waist circumference, improving lipid profile and medication adherence and physical activity, and had small significant effects in reducing BP and smoking cessation.	– Control group: both CR and no intervention. – Ten studies between 2003 and 2014 – Eleven studies used telephone calls as intervention.
Wongvibulsin *et al.*[45]	Safety: no; cost: no; effectiveness: yes; adherence: yes	Digital or telemedicine approaches for CR.	Not defined.	Not defined.	– Glycaemic control – BP – Anxiety/depression – Dietary habits – Exercise capacity – Lipid profile – QoL – Adherence – Smoking cessation – Weight management – Self-efficacy	TR was feasible and as effective as traditional CR in improving outcomes, whether as an adjunct or as an alternative to traditional CR.	– Systematic review. – 22% of included studies published before 2010. – No definition TR. – No defined control group.
Cost-effectiveness							
Scherrenberg *et al.* 2020[46]	Safety: no; cost: yes; effectiveness: no	TR with telephone, text messaging, email, smartphone application, smartwatch or pedometer-based interventions, video consultation, and internet-based interventions.	In-centre comprehensive Phase 2 CR or exercise-only CR.	Ischaemic heart disease, HF.	– Cost-effectiveness – Cost-utility	Eight studies, 751 patients. Seven out of eight studies demonstrated that TR may be as cost-effective as traditional centre-based CR.	– Systematic review only. – Well-defined TR intervention. – Large heterogeneity between studies.

Table A1 Continued

Paper	Focus	Intervention	Control group	Population/ condition	Outcomes	Results	Comments
Del Pino *et al.* 2022[47]	Safety: no; effectiveness: yes; cost: yes	TR, not specifically defined.	Not defined.	CVD (HF, ischaemic heart disease).	– Cost-effectiveness – Cost-utility	Five studies, 585 patients. TR may be as cost-effective as traditional centre-based CR.	– Systematic review only. – No defined TR intervention. – Large heterogeneity between studies.
Batalik *et al.* 2023[48]	Safety: no; cost: yes; effectiveness: no	Home-based TR intervention delivered by ICT (telephone, computer, internet, or videoconferencing) including the use of telemonitoring devices, and telephone calls.	Exercise-based centre-based CR.	Medical diagnosis of CVD.	– Cost-effectiveness – Cost-utility – Costs and benefits – Cost-minimization analysis	Twelve studies, 1554 patients. Most studies (92%) included in this systematic review found strong evidence that exercise-based TR is cost-effective.	– Systematic review only. – Well-defined TR intervention.

6MWD/6MWT, 6-min walking distance/test; BMI, body mass index; BP, blood pressure; CABG, coronary artery bypass graft; CHD, coronary heart disease; CR, cardiac rehabilitation; CVD, cardiovascular disease; COPD, chronic obstructive pulmonary disease; EQ-5D, EuroQol questionnaire; HbA1c, haemoglobin A1c; HF, Heart failure; LVEF, left ventricular ejection fraction; MLHFQ, Minnesota living with heart failure questionnaire; MMA, meta-meta.analyses; NYHA, New York Heart Association; PA, physical activity; PCI, percutaneous coronary intervention; PVO_2, peak rate of oxygen; QALY, quality-adjusted life year; QoL, quality of life; RCT, randomized controlled trial; SF, Short Form Health Survey; TR, telerehabilitation; VO_2max, maximum rate of oxygen.

Table A2 Additional standards

Structure-based—infrastructural

Minimal

- Dedicated area for initializing patients: wearable equipment and explanation material are available for starting up patients.
- Dedicated area for patient follow-up with dedicated computers and telephone equipment for daily follow-up of patients in the telerehabilitation programme.
- If needed, smartphones available for lease for patients not owning a smartphone.
- Wearable device for physical activity and other measurements.
- Remotely connectable (e.g. Bluetooth, 4G/5G) weighing scales.
- Remotely connectable (e.g. Bluetooth, 4G/5G) blood pressure cuffs.
- Licenses on dedicated smartphone applications.
- Dedicated digital tools for intermittent functional capacity testing (e.g. smartphone-based 6-min walking test).
- Wearable-based electrocardiography.
- Cuff-based connectable blood pressure cuff.
- Written instructions on home-based training goals (e.g. step count goals, heart rate zones, RPE goals, aerobic training goals, strength training goals).
- List of medical equipment and devices in use including details on maintenance and validity (if necessary).

Optimal

- Instruction videos on multiple aspects of the cardiac rehabilitation programme available on a digital platform (website, smartphone application) should be available.
- Digital module (e.g. through smartphone application) enabling group interventions, e.g. training groups guided by a dedicated exercise specialist.
- Licensed remote tests and questionnaires for screening of psychosocial status, nutritional status, quality of life, physical status, and medication adherence should be available.

Structure-based—human resources

Minimal

- Multidisciplinary team including at least one team member experienced in managing digital health technology (can be physiotherapist, nurse, nutritionist, and/or other).

Optimal

- Clear chief responsible person for the comprehensive telerehabilitation programme.
- Collaboration with related disciplines for co-management of digital health technologies and remote monitoring systems (e.g. endocrinology/diabetology for remote monitoring of diabetes, ideally in one integrated platform within the electronic health record).

Structure-based—Centre requirements

Minimal

- Protocol handling the adverse events and list of adverse events within the telerehabilitation programme.

Optimal

- Organizational team meetings on a 4 weeks basis or more frequently (which are documented), dedicated to the patients within the telerehabilitation programme.
- Organizational team meetings on a weekly basis (which are documented), dedicated to the patients within the telerehabilitation programme.
- Strategic plan, not more than 5 years old (including future perspectives, objectives, care programmes, patient safety and enhancement of quality of remote care).
- Annual evaluation report to monitor service delivery and outcomes.

Process-based

Minimal

- Telerehabilitation programme with at least the same duration as the conventional cardiac rehabilitation programme.
- Remote patient evaluation and risk factor identification.
- On-site exercise risk assessment (pre-exercise screening).
- Adherence to medication counselling through written information (e.g. web-based).

Continued

Table A2 Continued

- Physical activity written information (e.g. web-based).
- Individualized written exercise prescription and goals and/or video instructions on exercise training.
- Written instructions on nutritional goals and/or video instructions on nutritional goals.
- Written instructions and/or video instructions on alcohol consumption limitation.
- Written instructions and/or video instructions on weight control management.
- Monitoring equipment (e.g. connected weighing scale) for remote weight follow-up and management.
- Most recent lipid values easily available to the patient through patient version of electronic health record.
- Clear instructions on lipid goals for the patient (written or through visual dashboard).
- Remote hypertension management programme.
- Remote diabetes management programme (e.g. in collaboration with endocrinology/diabetology).
- Written instructions and/or video instructions on smoking cessation.
- Telephone-based remote smoking cessation counselling programme.
- Online module (web-based/smartphone application-based) module on smoking cessation.
- Remote follow-up of psychosocial management through licensed questionnaires and telephone consultation (after initial physical intake assessment).
- Plan at discharge including relapse prevention plan.

Optimal

- Telerehabilitation programme that extends to ≥double the duration of the conventional cardiac rehabilitation programme (e.g. 12-week sessions of hybrid rehabilitation programme + additional 12 weeks of continued telerehabilitation programme).
- Automated patient re-evaluation and update of risk factor status through automated remotely delivered questionnaires.
- Adherence to medication counselling through remotely delivered videos.
- Physical activity counselling through written information (e.g. web-based).
- Telephone counselling or web-based education programme available considering the following topics: driving, flying, sports, sexual activity, vocational/work-related information.
- Driving, flying, and sports counselling information videos available. Sexual counselling videos available. Vocational counselling videos available.
- Teleconsult for sexual counselling.
- Teleconsult for vocational counselling and support at request.
- Telerehabilitation programme screening for high-risk patients.
- Automatic referral of all patients with an indication for cardiac rehabilitation and/or CTR.
- Automatic assessment of patients with an indication through short questionnaire about willingness to participate in conventional cardiac rehabilitation, cardiac hybrid rehabilitation, and/or CTR.
- Baseline assessment including digital health literacy assessment to assess suitability for CTR programme and need for additional digital health training.
- Invitation of digitally fluent family members (e.g. children) to participate in helping the patient in the telerehabilitation programme.

References

1. Sidney S, Quesenberry CP Jr, Jaffe MG, Sorel M, Nguyen-Huynh MN, Kushi LH, *et al.* Recent trends in cardiovascular mortality in the United States and public health goals. *JAMA Cardiol* 2016;**1**:594–9. https://doi.org/10.1001/jamacardio.2016.1326
2. Kotseva K, De Backer G, De Bacquer D, Rydén L, Hoes A, Grobbee D, *et al.* Lifestyle and impact on cardiovascular risk factor control in coronary patients across 27 countries: results from the European Society of Cardiology ESC-EORP EUROASPIRE V registry. *Eur J Prev Cardiol* 2019;**26**:824–35. https://doi.org/10.1177/2047487318825350
3. Visseren FLJ, Mach F, Smulders YM, Carballo D, Koskinas KC, Bäck M, *et al.* 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. *Eur Heart J* 2021;**42**: 3227–337. Erratum in: Eur Heart J. 2022 Nov 7;43(42):4468. https://doi.org/10.1093/eurheartj/ehab484
4. Salzwedel A, Jensen K, Rauch B, Doherty P, Metzendorf MI, Hackbusch M, *et al.* Effectiveness of comprehensive cardiac rehabilitation in coronary artery disease patients treated according to contemporary evidence based medicine: update of the Cardiac Rehabilitation Outcome Study (CROS-II). *Eur J Prev Cardiol* 2020;**27**: 1756–74. https://doi.org/10.1177/2047487320905719
5. Shields GE, Wells A, Doherty P, Heagerty A, Buck D, Davies LM. Cost-effectiveness of cardiac rehabilitation: a systematic review. *Heart* 2018;**104**:1403–10. https://doi.org/10.1136/heartjnl-2017-312809
6. Molloy CD, Long L, Mordi IR, Bridges C, Sagar VA, Davies EJ, *et al.* Exercise-based cardiac rehabilitation for adults with heart failure—2023 cochrane systematic review and meta-analysis. *Eur J Heart Fail* 2023;**25**:2263–73. https://doi.org/10.1002/ejhf.3046
7. Dibben GO, Faulkner J, Oldridge N, Rees K, Thompson DR, Zwisler AD, *et al.* Exercise-based cardiac rehabilitation for coronary heart disease: a meta-analysis. *Eur Heart J* 2023;**44**:452–69. https://doi.org/10.1093/eurheartj/ehac747
8. Ambrosetti M, Abreu A, Corrà U, Davos CH, Hansen D, Frederix I, *et al.* Secondary prevention through comprehensive cardiovascular rehabilitation: from knowledge to implementation. 2020 update. A position paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology. *Eur J Prev Cardiol* 2021;**28**:460–95. https://doi.org/10.1177/2047487320913379
9. Dendale P, Scherrenberg M, Sivakova O, Frederix I. Prevention: from the cradle to the grave and beyond. *Eur J Prev Cardiol* 2019;**26**:507–11. https://doi.org/10.1177/2047487318821772

10. Resurrección DM, Moreno-Peral P, Gómez-Herranz M, Rubio-Valera M, Pastor L, Caldas de Almeida JM, *et al.* Factors associated with non-participation in and dropout from cardiac rehabilitation programmes: a systematic review of prospective cohort studies. *Eur J Cardiovasc Nurs* 2019;**18**:38–47. https://doi.org/10.1177/1474515118783157
11. Scherrenberg M, Wilhelm M, Hansen D, Völler H, Cornelissen V, Frederix I, *et al.* The future is now: a call for action for cardiac telerehabilitation in the COVID-19 pandemic from the secondary prevention and rehabilitation section of the European Association of Preventive Cardiology. *Eur J Prev Cardiol* 2021;**28**:524–40. https://doi.org/10.1177/2047487320939671
12. Abreu A, Frederix I, Dendale P, Janssen A, Doherty P, Piepoli MF, *et al.* Standardization and quality improvement of secondary prevention through cardiovascular rehabilitation programmes in Europe: the avenue towards EAPC accreditation programme: a position statement of the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology (EAPC). *Eur J Prev Cardiol* 2021;**28**:496–509. https://doi.org/10.1177/2047487320924912
13. Ramachandran HJ, Jiang Y, Tam WWS, Yeo TJ, Wang W. Effectiveness of home-based cardiac telerehabilitation as an alternative to Phase 2 cardiac rehabilitation of coronary heart disease: a systematic review and meta-analysis. *Eur J Prev Cardiol* 2022;**29**:1017–43. https://doi.org/10.1093/eurjpc/zwab106
14. Falter M, Scherrenberg M, Kindermans H, Kizilkilic S, Kaihara T, Dendale P. Willingness to participate in cardiac telerehabilitation: results from semi-structured interviews. *Eur Heart J Digit Health* 2021;**3**:67–76. https://doi.org/10.1093/ehjdh/ztab091
15. Frederix I, Caiani EG, Dendale P, Anker S, Bax J, Böhm A, *et al.* ESC e-Cardiology Working Group Position Paper: overcoming challenges in digital health implementation in cardiovascular medicine. *Eur J Prev Cardiol* 2019;**26**:1166–77. https://doi.org/10.1177/2047487319832394
16. Caiani EG, Kemps H, Hoogendoorn P, Asteggiano R, Böhm A, Borregaard B, *et al.* Standardized assessment of evidence supporting the adoption of mobile health solutions: a Clinical Consensus Statement of the ESC Regulatory Affairs Committee: developed in collaboration with the European Heart Rhythm Association (EHRA), the Association of Cardiovascular Nursing & Allied Professions (ACNAP) of the ESC, the Heart Failure Association (HFA) of the ESC, the ESC Young Community, the ESC Working Group on e-Cardiology, the ESC Council for Cardiology Practice, the ESC Council of Cardio-Oncology, the ESC Council on Hypertension, the ESC Patient Forum, the ESC Digital Health Committee, and the European Association of Preventive Cardiology (EAPC). *Euro Heart J—Digital Health* 2024; https://doi.org/10.1093/ehjdh/ztae042
17. Brouwers RWM, Scherrenberg M, Kemps HMC, Dendale P, Snoek JA. Cardiac telerehabilitation: current status and future perspectives. *Neth Heart J* 2024;**32**:31–7. https://doi.org/10.1007/s12471-023-01833-9
18. Piotrowicz E, Pencina MJ, Opolski G, Zareba W, Banach M, Kowalik I, *et al.* Effects of a 9-week hybrid comprehensive telerehabilitation program on long-term outcomes in patients with heart failure: the telerehabilitation in heart failure patients (TELEREH-HF) randomized clinical trial. *JAMA Cardiol* 2020;**5**:300–8. https://doi.org/10.1001/jamacardio.2019.5006
19. Frederix I, Solmi F, Piepoli MF, Dendale P. Cardiac telerehabilitation: a novel cost-efficient care delivery strategy that can induce long-term health benefits. *Eur J Prev Cardiol* 2017;**24**:1708–17. https://doi.org/10.1177/2047487317732274
20. Kraal JJ, Van den Akker-Van Marle ME, Abu-Hanna A, Stut W, Peek N, Kemps HM. Clinical and cost-effectiveness of home-based cardiac rehabilitation compared to conventional, centre-based cardiac rehabilitation: results of the FIT@Home study. *Eur J Prev Cardiol* 2017;**24**:1260–73. https://doi.org/10.1177/2047487317710803
21. Belbasis L, Bellou V, Ioannidis JPA. Conducting umbrella reviews. *BMJ Med* 2022;**1**:e000071. https://doi.org/10.1136/bmjmed-2021-000071
22. Isernia S, Pagliari C, Morici N, Toccafondi A, Banfi PI, Rossetto F, *et al.* Telerehabilitation approaches for people with chronic heart failure: a systematic review and meta-analysis. *J Clin Med* 2022;**12**:64. https://doi.org/10.3390/jcm12010064
23. Cordeiro ALL, da Silva Miranda A, de Almeida HM, Santos P. Quality of life in patients with heart failure assisted by telerehabilitation: a systematic review and meta-analysis. *Int J Telerehabil* 2022;**14**:e6456. https://doi.org/10.5195/ijt.2022.6456
24. Cavalheiro AH, Silva Cardoso J, Rocha A, Moreira E, Azevedo LF. Effectiveness of tele-rehabilitation programs in heart failure: a systematic review and meta-analysis. *Health Serv Insights* 2021;**14**:11786329211021668. https://doi.org/10.1177/11786329211021668
25. Gao Y, Wang N, Zhang L, Liu N. Effectiveness of home-based cardiac telerehabilitation in patients with heart failure: a systematic review and meta-analysis of randomised controlled trials. *J Clin Nurs* 2023;**32**:7661–76. https://doi.org/10.1111/jocn.16726
26. Chan C, Yamabayashi C, Syed N, Kirkham A, Camp PG. Exercise telemonitoring and telerehabilitation compared with traditional cardiac and pulmonary rehabilitation: a systematic review and meta-analysis. *Physiother Can* 2016;**68**:242–51. https://doi.org/10.3138/ptc.2015-33
27. Hwang R, Bruning J, Morris N, Mandrusiak A, Russell T. A systematic review of the effects of telerehabilitation in patients with cardiopulmonary diseases. *J Cardiopulm Rehabil Prev* 2015;**35**:380–9. https://doi.org/10.1097/HCR.0000000000000121
28. Jin Choo Y, Chang MC. Effects of telecardiac rehabilitation on coronary heart disease: a PRISMA-compliant systematic review and meta-analysis. *Medicine (Baltimore)* 2022;**101**:e29459. https://doi.org/10.1097/MD.0000000000029459
29. Stefanakis M, Batalik L, Antoniou V, Pepera G. Safety of home-based cardiac rehabilitation: a systematic review. *Heart Lung* 2022;**55**:117–26. https://doi.org/10.1016/j.hrtlng.2022.04.016
30. Nacarato D, Sardeli AV, Mariano LO, Chacon-Mikahil MPT. Cardiovascular telerehabilitation improves functional capacity, cardiorespiratory fitness and quality of life in older adults: a systematic review and meta-analysis. *J Telemed Telecare* 2024;**30**:1238–48. https://doi.org/10.1177/1357633X221137626
31. Leslie S, Tan J, McRae PJ, O'leary SP, Adsett JA. The effectiveness of exercise interventions supported by telerehabilitation for recently hospitalized adult medical patients: a systematic review. *Int J Telerehabil* 2021;**13**:e6356. https://doi.org/10.5195/ijt.2021.6356
32. Wu C, Li Y, Chen J. Hybrid versus traditional cardiac rehabilitation models: a systematic review and meta-analysis. *Kardiol Pol* 2018;**76**:1717–24. https://doi.org/10.5603/KP.a2018.0175
33. Yang Z, Jia X, Li J, Mei Z, Yang L, Yan C, *et al.* Efficacy and safety of hybrid comprehensive telerehabilitation (HCTR) for cardiac rehabilitation in patients with cardiovascular disease: a systematic review and meta-analysis of randomized controlled trials. *Occup Ther Int* 2023;**2023**:5147805. https://doi.org/10.1155/2023/5147805
34. Zhong W, Fu C, Xu L, Sun X, Wang S, He C, *et al.* Effects of home-based cardiac telerehabilitation programs in patients undergoing percutaneous coronary intervention: a systematic review and meta-analysis. *BMC Cardiovasc Disord* 2023;**23**:101. https://doi.org/10.1186/s12872-023-03120-2
35. Zhong W, Liu R, Cheng H, Xu L, Wang L, He C, *et al.* Longer-term effects of cardiac telerehabilitation on patients with coronary artery disease: systematic review and meta-analysis. *JMIR Mhealth Uhealth* 2023;**11**:e46359. https://doi.org/10.2196/46359
36. Brørs G, Pettersen TR, Hansen TB, Fridlund B, Hølvold LB, Lund H, *et al.* Modes of e-Health delivery in secondary prevention programmes for patients with coronary artery disease: a systematic review. *BMC Health Serv Res* 2019;**19**:364. https://doi.org/10.1186/s12913-019-4106-1
37. Chong MS, Sit JWH, Karthikesu K, Chair SY. Effectiveness of technology-assisted cardiac rehabilitation: a systematic review and meta-analysis. *Int J Nurs Stud* 2021;**124**:104087. https://doi.org/10.1016/j.ijnurstu.2021.104087
38. Devi R, Singh SJ, Powell J, Fulton EA, Igbinedion E, Rees K. Internet-based interventions for the secondary prevention of coronary heart disease. *Cochrane Database Syst Rev* 2015;**2015**:CD009386. https://doi.org/10.1002/14651858.CD009386.pub2
39. Murphy AC, Meehan G, Koshy AN, Kunniardy P, Farouque O, Yudi MB. Efficacy of smartphone-based secondary preventive strategies in coronary artery disease. *Clin Med Insights Cardiol* 2020;**14**:1179546820927402. https://doi.org/10.1177/1179546820927402
40. Su JJ, Yu DSF, Paguio JT. Effect of eHealth cardiac rehabilitation on health outcomes of coronary heart disease patients: a systematic review and meta-analysis. *J Adv Nurs* 2020;**76**:754–72. https://doi.org/10.1111/jan.14272
41. Rawstorn JC, Gant N, Direito A, Beckmann C, Maddison R. Telehealth exercise-based cardiac rehabilitation: a systematic review and meta-analysis. *Heart* 2016;**102**:1183–92. https://doi.org/10.1136/heartjnl-2015-308966
42. Gandhi S, Chen S, Hong L, Sun K, Gong E, Li C, *et al.* Effect of mobile health interventions on the secondary prevention of cardiovascular disease: systematic review and meta-analysis. *Can J Cardiol* 2017;**33**:219–31. https://doi.org/10.1016/j.cjca.2016.08.017
43. Jin K, Khonsari S, Gallagher R, Gallagher P, Clark AM, Freedman B, *et al.* Telehealth interventions for the secondary prevention of coronary heart disease: a systematic review and meta-analysis. *Eur J Cardiovasc Nurs* 2019;**18**:260–71. https://doi.org/10.1177/1474515119826510
44. Turan Kavradim S, Özer Z, Boz İ. Effectiveness of telehealth interventions as a part of secondary prevention in coronary artery disease: a systematic review and meta-analysis. *Scand J Caring Sci* 2020;**34**:585–603. https://doi.org/10.1111/scs.12785
45. Wongvibulsin S, Habeos EE, Huynh PP, Xun H, Shan R, Porosnicu Rodriguez KA, *et al.* Digital health interventions for cardiac rehabilitation: systematic literature review. *J Med Internet Res* 2021;**23**:e18773. https://doi.org/10.2196/18773
46. Scherrenberg M, Falter M, Dendale P. Cost-effectiveness of cardiac telerehabilitation in coronary artery disease and heart failure patients: systematic review of randomized controlled trials. *Eur Heart J Digit Health* 2020;**1**:20–9. https://doi.org/10.1093/ehjdh/ztaa005
47. Del Pino R, Díez-Cirarda M, Ustarroz-Aguirre I, Gonzalez-Larragan S, Caprino M, Busnatu S, *et al.* Costs and effects of telerehabilitation in neurological and cardiological diseases: a systematic review. *Front Med (Lausanne)* 2022;**9**:832229. https://doi.org/10.3389/fmed.2022.832229
48. Batalik L, Filakova K, Sladeckova M, Dosbaba F, Su J, Pepera G. The cost-effectiveness of exercise-based cardiac telerehabilitation intervention: a systematic review. *Eur J Phys Rehabil Med* 2023;**59**:248–58. https://doi.org/10.23736/S1973-9087.23.07773-0
49. Schmidt C, Magalhães S, Gois Basilio P, Santos C, Oliveira MI, Ferreira JP, *et al.* Center- vs home-based cardiac rehabilitation in patients with heart failure: EXIT-HF randomized controlled trial. *JACC Heart Fail* 2025;**13**:695–706. https://doi.org/10.1016/j.jchf.2024.09.024

50. Tegegne TK, Rawstorn JC, Nourse RA, Kibret KT, Ahmed KY, Maddison R. Effects of exercise-based cardiac rehabilitation delivery modes on exercise capacity and health-related quality of life in heart failure: a systematic review and network meta-analysis. *Open Heart* 2022;**9**:e001949. https://doi.org/10.1136/openhrt-2021-001949
51. McDonagh ST, Dalal H, Moore S, Clark CE, Dean SG, Jolly K, *et al.* Home-based versus centre-based cardiac rehabilitation. *Cochrane Database Syst Rev* 2023;**10**:CD007130. https://doi.org/10.1002/14651858.CD007130.pub5
52. Shi W, Green H, Sikhosana N, Fernandez R. Effectiveness of telehealth cardiac rehabilitation programs on health outcomes of patients with coronary heart diseases: an umbrella review. *J Cardiopulm Rehabil Prev* 2024;**44**:15–25. https://doi.org/10.1097/HCR.0000000000000807
53. Aktaa S, Batra G, Wallentin L, Baigent C, Erlinge D, James S, *et al.* European Society of Cardiology methodology for the development of quality indicators for the quantification of cardiovascular care and outcomes. *Eur Heart J Qual Care Clin Outcomes* 2022; **8**:4–13. https://doi.org/10.1093/ehjqcco/qcaa069
54. Bock BC, Carmona-Barros RE, Esler JL, Tilkemeier PL. Program participation and physical activity maintenance after cardiac rehabilitation. *Behav Modif* 2003;**27**:37–53. https://doi.org/10.1177/0145445502238692
55. Lunde P, Bye A, Bergland A, Grimsmo J, Jarstad E, Nilsson BB. Long-term follow-up with a smartphone application improves exercise capacity post cardiac rehabilitation: a randomized controlled trial. *Eur J Prev Cardiol* 2020;**27**:1782–92. https://doi.org/10.1177/2047487320905717
56. Brouwers RWM, Kraal JJ, Regis M, Spee RF, Kemps HMC. Effectiveness of cardiac telerehabilitation with relapse prevention: SmartCare-CAD randomized controlled trial. *J Am Coll Cardiol* 2021;**77**:2754–6. https://doi.org/10.1016/j.jacc.2021.03.328
57. Arias López MDP, Ong BA, Borrat Frigola X, Fernández AL, Hicklent RS, Obeles AJT, *et al.* Digital literacy as a new determinant of health: a scoping review. *PLOS Digit Health* 2023;**2**:e0000279. https://doi.org/10.1371/journal.pdig.0000279
58. Ferreira-Brito F, Alves S, Guerreiro T, Santos O, Caneiras C, Carriço L, *et al.* Digital health and patient adherence: a qualitative study in older adults. *Digit Health* 2024;**10**: 20552076231223805. https://doi.org/10.1177/20552076231223805
59. Scherrenberg M, Falter M, Kaihara T, Xu L, van Leunen M, Kemps H, *et al.* Development and internal validation of the digital health readiness questionnaire: prospective single-center survey study. *J Med Internet Res* 2023;**25**:e41615. https://doi.org/10.2196/41615
60. Scherrenberg M, Zeymer U, Schneider S, Van der Velde AE, Wilhelm M, Van't Hof AWJ, *et al.* EU-CaRE study: could exercise-based cardiac telerehabilitation also be cost-effective in elderly? *Int J Cardiol* 2021;**340**:1–6. https://doi.org/10.1016/j.ijcard.2021.08.024
61. Kobeissi MM, Hickey JV. An infrastructure to provide safer, higher-quality, and more equitable telehealth. *Jt Comm J Qual Patient Saf* 2023;**49**:213–22. https://doi.org/10.1016/j.jcjq.2023.01.006
62. European Parliament and Council of the European Union. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data (General Data Protection Regulation). *Official Journal of the European Union* 2016;**L119**, 1–88.
63. Rodriguez A, Tuck C, Dozier MF, Lewis SC, Eldridge S, Jackson T, *et al.* Current recommendations/practices for anonymising data from clinical trials in order to make it available for sharing: a scoping review. *Clin Trials* 2022;**19**:452–63. https://doi.org/10.1177/17407745221087469
64. Palacholla RS, Fischer N, Coleman A, Agboola S, Kirley K, Felsted J, *et al.* Provider- and patient-related barriers to and facilitators of digital health technology adoption for hypertension management: scoping review. *JMIR Cardio* 2019;**3**:e11951. https://doi.org/10.2196/11951
65. Golbus JR, Lopez-Jimenez F, Barac A, Cornwell WK 3rd, Dunn P, Forman DE, *et al.* Digital technologies in cardiac rehabilitation: a science advisory from the American Heart Association. *Circulation* 2023;**148**:95–107. https://doi.org/10.1161/CIR.0000000000001150