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REVIEW ARTICLE

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Completeness of intervention reporting in randomised trials of technology-enabled remote or hybrid exercise-based cardiac rehabilitation: a systematic review using the TIDieR framework

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ABSTRACT

Background: Exercise-based cardiac rehabilitation improves clinical outcomes and quality of life. Technology-enabled delivery of remote cardiac rehabilitation is as effective in improving health outcomes as in-person delivery and has the potential to transform clinical service delivery. However, for the successful translation of research to clinical practice, interventions must be adequately reported in the literature.

Methods: Systematic review of MedLine, CINAHL, PubMed and SPORT Discus databases applying PRISMA guidance. Randomised controlled trials of remote or hybrid technology-enabled exercise-based cardiac rehabilitation interventions were included. Completeness of reporting was evaluated against the TIDieR checklist.

Results: The search strategy returned 162 articles which, following screening, resulted in 12 randomised trials being included containing data for 1588 participants. No trial fully reported their rehabilitation intervention as per the 12-item TIDieR checklist, with a median score of eight out of 12 categories. Notably, intervention detail, dosage and modification were comparatively poorly reported.

Conclusion: Technology-enabled remotely delivered cardiac rehabilitation may be effective at improving cardiovascular fitness; however, the quality of reporting of these interventions in randomised trials is insufficient for replication which has material implications for translation into clinical practice.

> IMPLICATIONS FOR REHABILITATION

- Technology-enabled remotely delivered cardiac rehabilitation is effective at improving cardiovascular fitness, and thought to be equivalent to centre-based delivery.
- The quality of the reporting of these rehabilitation interventions as per the TIDieR checklist in randomised trials is, however, insufficient for replication of these studies or for uptake and 'roll-out' across clincial practice.
- Full reporting of rehabilitation interventions is essential to improve the translation of research evidence into clinical practice and the rehabilitation trial literature

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Introduction

When properly designed and implemented, randomised controlled trials provide gold-standard evidence as to the effectiveness of interventions and treatments. However, suboptimal reporting of research raises questions the validity of the findings and impairs reproduction and translation of the work. Poor quality reporting of RCTs is especially concerning as their findings play an important role in clinical decision making and in health policy formation.

Cardiovascular Disease (CVD) is the leading cause of mortality globally, accounting for almost 18 million annual deaths worldwide [1]. Cardiac rehabilitation (CR) is a secondary prevention lifestyle education and exercise programme which reduces rates of mortality, recurrence of myocardial infarction, rates of major adverse cardiac events, the need for repeat surgical reperfusion and improves health related quality of life [2]. Despite such clear benefits, both attendance and adherence to traditional "centre-based" cardiac rehabilitation (where patients attend in-person, medically supervised, classes at a hospital or clinic facility) is low [3].

Tele-rehabilitation and home-based rehabilitation are increasingly accepted as viable alternative delivery methods for CR that enhance accessibility and compliance [4]. In contrast to traditional centre-based CR services, these interventions rely primarily on indirect exercise supervision. Remote cardiac rehabilitation has been successfully introduced in many countries (notably in the United Kingdom, Europe and Canada), and rollout of these services amplified by the recent COVID-19 pandemic, where face-to-face 'non-essential' healthcare was suspended [5]. The move to remote-based CR services is not without controversy however, with some healthcare systems reticent to change. The most recent combined position statement on home-based CR from the American Association of Cardiovascular and Pulmonary

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Rehabilitation, the American Heart Association and the American College of Cardiology notes that while alternatives to centre-based cardiac rehabilitation hold promise, there are concerns as to standardisation of interventions using remote delivery methods, and questions as to the evidence-base for these programmes [6]. Systematic review of home vs centre-based CR by these clinical groups and also the current Cochrane review on this topic [7] highlight that similar clinical outcomes are achieved in either rehabilitation setting, but both reviews note inconclusive risk of bias assessments of the trials that were included. Alongside uncertainty as to selection bias, of particular note were questions around intervention dosage and intensity [6,7].

The clinical concerns as to remote CR are mainly due to a perceived lack of medical supervision of the rehabilitation, particularly around cardiovascular exercise monitoring and safety. More recently, communication and telemetry technologies, and the infrastructure to support real-time monitoring, have matured, and have been employed in the CR setting to address these concerns. While the addition of digital interventions to rehabilitation regimes has been demonstrated to enhance adherence to exercise-based interventions [8], in the cardiac rehabilitation setting, the use of technology such as heart rate monitors, smartphone applications and text messaging, has also allowed the delivery of effective remotely monitored rehabilitation [6]. Two recent meta-analyses have evaluated the effectiveness of technology-facilitated home-based, cardiac rehabilitation compared to traditional delivery [9,10], and found no deficit in clinical and heath-related quality of life outcomes. The focus of the scientific literature as to the technology-enabled trials has though been on the evaluation of the introduction of these programmes, and the clinical outcomes achieved compared to traditional delivery methods. Quality assessment of the individual trials of technology-enabled CR do suggest a generally low risk of bias [9,10]; however, the reporting of the underlying exercise rehabilitation interventions employed within these trials has not been considered.

Incomplete reporting of study interventions, or of the processes around these, compromises the repeatability of the study and impairs translation of successful interventions to wider clinical practice. Further, incomplete detail as to the conduct of trial interventions can affect the ability to interpret treatment effects, and raises concerns as to the validity and reliability of trial findings. Unfortunately, inadequate reporting of trial interventions is a recognized problem within biomedical research, which led to the creation of the Template for Intervention Description and Replication (TIDieR) [11] checklist. TIDieR is well-established and promoted by the EQUATOR (Enhancing the QUAlity and Transparency Of health Research) Network as a tool for researchers to guide the development, implementation and reporting of study interventions to ensure all critical details are considered [11]. This study therefore aimed to evaluate the quality of intervention reporting in randomised controlled trials of technology-enabled, remote cardiac rehabilitation interventions.

Methods

A systematic review of trials investigating the efficacy of technology-enabled remote or hybrid cardiac rehabilitation in comparison to usual care in patients was undertaken, in line with the predetermined protocol available *via* the Open Science Framework (doi.org/10.17605/OSF.IO/DCMAV). The study is reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [12].

Search strategy

The search strategy was devised in conjunction with a subject specialist librarian based on the Population, Intervention, Comparison and Outcome (PICO) framework and using medical subject headings. Details of the PICO and search are provided in the supplemental material. Searches were conducted in CINAHL, Medline, PubMed, and SPORT Discus databases until the 31st December 2022. The reference lists of included manuscripts were manually searched for additional relevant articles.

Eligibility criteria

Eligibility criteria were defined by the PICO. Randomised controlled trials evaluating a change in physical fitness or exercise capacity in patients undertaking an exercise-based cardiac rehabilitation with a remote or hybrid component supported by technology were considered. Where relevant (and specifically directed in the trial report) previously published trial protocols were used to obtain detail as to the trial interventions.

We were interested in quality of reporting of exercise interventions in studies that evaluated a technology-enabled home-based intervention. As such we considered effectiveness trials investigating an outcome of cardiovascular fitness to ensure the exercise-rehabilitation interventions evaluated were specifically directed at improving cardiovascular health.

Accepted interventions were fully remote, or hybrid, exercise-based cardiac rehabilitation that were monitored remotely through technological means versus usual care, which was justified as existing local practice. Both traditional outpatient exercise-based cardiac rehabilitation and non-exercise-based rehabilitation were accepted as usual care for the purpose of this review that focusses on the quality of reporting of the digitally supported intervention.

The search was limited to studies published from 1998 due to the change in cardiac rehabilitation guidelines at that time [13]. Accepted study populations were adults (>18 years of age) diagnosed with acute coronary syndromes including ST elevation myocardial infarction, non-ST elevation myocardial infarction, and unstable angina. Chronic cardiovascular disease that required preventative interventions including percutaneous coronary intervention or coronary artery bypass were also included; however, studies reporting interventions in patients with heart failure were excluded due to differences in disease pathophysiology and expected response to rehabilitation.

Study selection

A three-part screening strategy was employed to identify relevant articles. One investigator (AM) carried out the searches and screened by title. Abstracts were reviewed independently by two investigators (AM and SM) and consensus reached for full-text inclusion. In the event of disagreement, or doubt, manuscripts were included for full text review. Full texts were reviewed by the same two reviewers independently and selection agreed by consensus with a third independent reviewer (CH).

Data extraction

Data were extracted using a bespoke Excel database by two reviewers (AM and SM) with agreement by consensus. Data sought included the year of publication, geographic location where the trial was conducted, number of participants, numbers of male and females included, a description of the rehabilitation intervention (including the exercise intensity, the session duration and the frequency of sessions), the monitoring technology employed and the measure of cardiovascular fitness used.

TIDieR checklist

Data on quality of reporting were separately extracted using the TIDieR checklist by two reviewers (AM and DFH) with agreement by consensus. The TIDieR checklist consists of 12 items that cover the who, what, where, when, how and why aspects of the intervention under consideration. Specifically questions relate to the name of the intervention; the rationale, theory or goal; the materials used in delivering the intervention; the procedures, activities and processes; who provided the intervention; the mechanism or mode of delivery; the location or setting; the number of sessions; whether the intervention was tailored or personalised; if any modifications were made; if adherence was assessed, and the fidelity achieved (extent to which the intervention was delivered as planned).

We scored the selected studies by allocating one point for each parameter adequately described with a maximum possible score of twelve. No points were awarded to questions where if the information was absent or insufficient for replication. Information was accepted if it was available within the published paper, or if separately provided in publicly available trial protocols or additional documentation, but only in cases where the published trial report specifically referenced such documents.

Results

Study selection

The database search identified 215 results of which 149 remained after the removal of duplicates. An additional 13 studies were

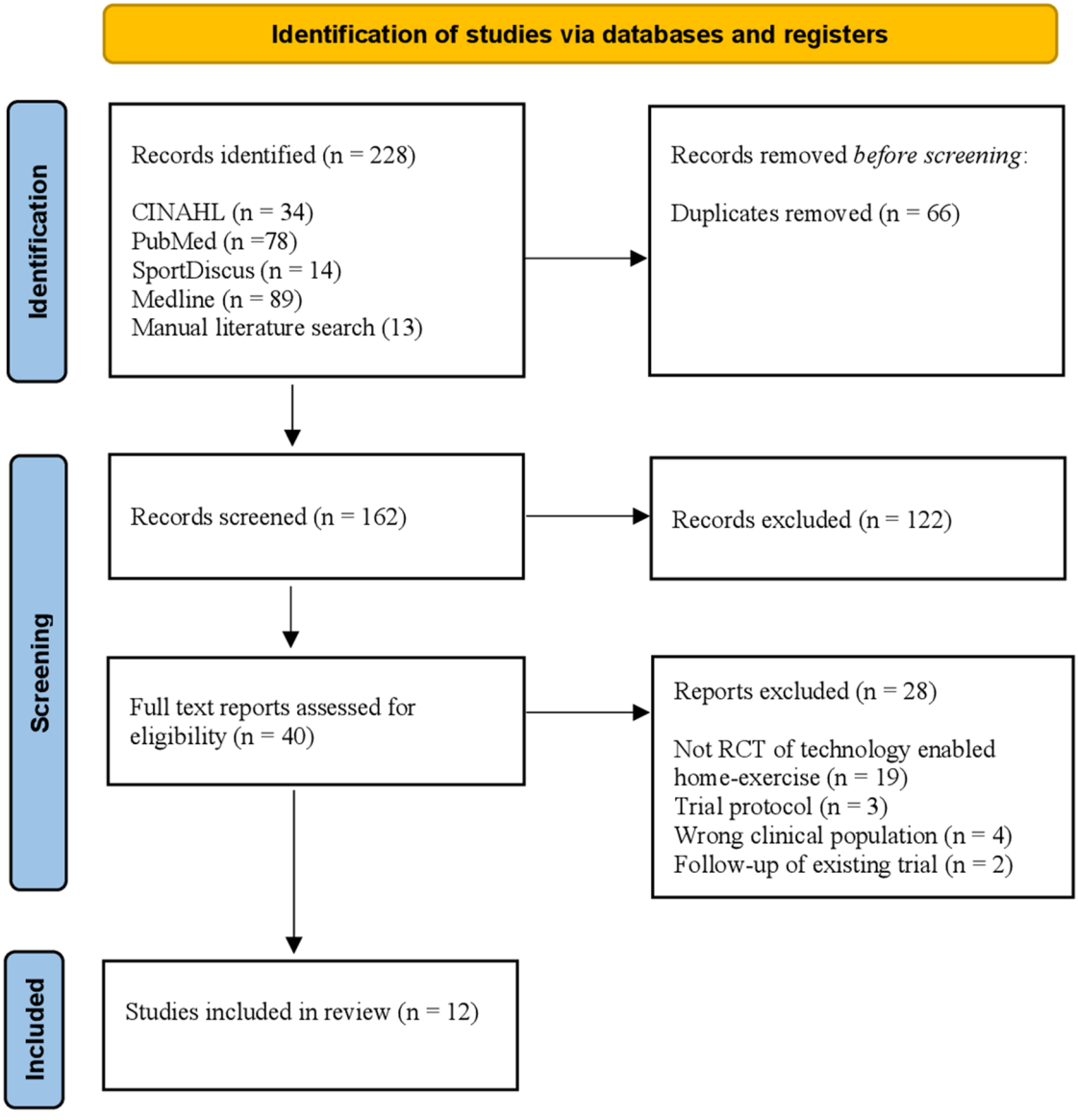

Figure 1. PRISMA flowchart.

identified through reference searching. As such 162 articles were screened and, of these, 40 papers were eligible for full-text review. Of the 40 papers, 12 met the eligibility criteria and were included in the final review (Figure 1).

Study characteristics

The main study characteristics are described in Table 1. All studies included were parallel group RCTs. A combined total of 1588 participants were included in the trials, 799 randomised to the intervention groups and 789 to the controls. The sample sizes for the trials ranged from 32 to 300. Of the included studies 1333 (84%) participants were male and 255 (16%) were female.

Three studies were carried out in Australia [14–16], two in Canada [17,18], two in the Netherlands [19,20], and one in each of Spain [21], Denmark [22], China [23], and Portugal [24]. The remaining study [25] was conducted across five EU countries including the Netherlands, Denmark, Spain, France and Switzerland.

The predominant technology used in the included trials was digital communication, with all 12 employing some form of remote telephone monitoring of participants. Smart technology was employed in six studies [14–16,18,19,21] for the delivery of the rehabilitation interventions via smartphone applications and webpages. Again, half of the studies (6 of 12) [14,18–20,23,25] employed remote heart rate monitoring via a wearable chest strap, and two [20,24] utilized the smartphone accelerometer function to quantify activity.

Usual care varied considerably within included studies with seven trials utilizing traditional, outpatient exercise-based cardiac rehabilitation [14–17,19–21]. The other five trials provided non-exercise cardiac rehabilitation interventions as the control [18,22–25]. Substantial variation in content and delivery was evident across the 12 trials (Table 1).

Quality of intervention reporting

Using the TIDieR intervention reporting checklist, papers were evaluated against a maximal possible score of achieving 12 criteria. According to this methodology, no study fully reported their cardiac rehabilitation intervention (Figure 2). Median score for the included trials was 8/12 criteria adequately reported, with substantial variation evident across the studies (range 6/12 to 11/12). Five of the trials [14,16,19,22,24] achieved a score in excess of the group median, with three reaching 11/12 [14,19,24]. Seven trials [15,17,18,20,21,23,25] reported only 6–8 of the 12 TIDieR aspects adequately (Figure 2).

There was a large variability in the frequency of completion of the individual TIDieR checklist items (Figure 3). Four criteria were reported by all RCTs (Intervention name, rationale, mode and location of delivery) however whether modifications were made to the intervention was reported in only 2 cases. Details as to the procedures followed were reported adequately by only half of the RCTs and the dosages applied, providers of the intervention, and the successful delivery of the intervention were described in only 7 of the 12 included trial reports (Figure 3).

Discussion

This evaluation as to the reporting of technology-enabled cardiac rehabilitation within randomised controlled trials found inadequate documentation of important intervention details that are required to replicate the work or to effectively implement the rehabilitation programme in wider practice. Modern technology-enabled delivery of remote cardiac rehabilitation has the potential to transform clinical service delivery, reduce morbidity, and save lives, through increased uptake of such rehabilitation programs where attendance at clinical facilities is difficult (such as in geographically remote areas) or where adherence to in-person classes is challenging. These technology-enabled remote interventions have been shown to be non-inferior to centre-based rehabilitation [10] which should encourage roll out of these digitally enhanced services. To do so successfully; however, the trial interventions must be replicated.

Exercise-based rehabilitation is something of a generic term that incorporates a variety of modes, types, and dosages (frequency, intensity and duration). These parameters can result in very different physiological stresses and expected physiological adaptations to the rehabilitation intervention. Historically there has been no guidance as to how exercise-based rehabilitation interventions should be reported, and there is a problematic legacy across the rehabilitation literature of poor and incomplete reporting as a result [26]. The introduction and adoption of the Consolidated Standards of Reporting Trials (CONSORT) statement for reporting clinical trials in the late 1990s has improved the general documentation of trial conduct and results, however only a single CONSORT checklist item relates to the reporting of the intervention itself and allows for substantial variability in the depth of this reporting in trial reports. This was recognised as a significant issue in biomedical research and the TIDieR checklist created to address this vital aspect of study reporting [11]. Unfortunately, despite progress in reporting guidelines, our finding of incomplete intervention reporting is typical of the wider rehabilitation literature. That a median eight of 12 categories of the TIDieR checklist were adequately reported in the context of remote technology-enabled cardiac rehabilitation corresponds to recent reviews of exercise intervention reporting post-stroke [27], peripheral arterial disease [28], hip osteoarthritis [29], and cancer [30]. This issue is of incomplete intervention reporting is not restricted to exercise interventions but widespread. Webster et al. highlight respectively that, on average, only eight out of 12 TIDieR items are adequately reported in placebo and sham-controlled trials in the leading specialist medical journals [31], and Palmer et al. find the same across cardiovascular trials [32].

Within the headline figure of a median eight of 12 TIDieR categories reported appropriately across the trials, we also found notable variability in the frequency of completion of individual TIDieR checklist items. Frustratingly, vital aspects such as the detail as to the procedures followed were reported adequately by only half of the RCTs. Details as to the dosages applied, providers of the intervention, and the successful delivery of the intervention (fidelity) fared only slightly better with 7 of the 12 included trial reports documenting this reliably. This is particularly disappointing as these questions relate to critical aspects of rehabilitation delivery that in the context of an exercise-based trial are as essential as the drug dosage or the surgical workflow. The TIDieR checklist was not specifically developed for exercise–based interventions. However, the information that would be required for the application of the FITT principles [33] (Frequency, Intensity, Time and Type) are suitably covered. Frequency, intensity and time are reportable under TIDieR item 8 ("When and How Much") which requests the number of times the intervention was delivered and over what period of time including the number of sessions, their schedule, and their duration, intensity or dose. The last of the FITT principles, type, falls under TIDieR item 4 ("what Procedures?") which states studies should include descriptions of "each of

Table 1. Description of included randomised trials.

Author (year of publication) Region trial conducted	Clinical population n (% female) n, Intervention/ control	Trial Intervention	Trial Control	Technology employed	Cardiovascular outcomes and between group differences
Peydro et al. (2022) Spain [21]	acute coronary syndrome 59 (8%) 31/28	Cardiac telerehabilitation. 2x weeks hospital-based training (4x supervised exercise sessions) setting pace to heartrate. Followed by smartphone app guided daily sessions for 10 months. Intensity set at 60-80 HR reserve based on a baseline treadmill test.	Centre-based CR. 2x sessions per week for 8 weeks. 16x supervised sessions of routine workouts and cycle training. Intensity set at 60-80% HR reserve based on a baseline treadmill test.	Webpage that allowed personalized healthcare and tracking of patient adherence to recommendations and smartphone application that allowed daily scheduling of exercise sessions; recording of general condition, vital signs, and medication adherence.	Superior outcome in intervention group ($p = 0.045$) in Self-reported physical activity (IPAQ survey) at 10-months. No between group difference ($p = 0.24$) in mean VO_2max increase at 10-months.
Snoek et al. (2021) Netherlands, Denmark, France, Switzerland, Spain. [25]	elderly patients with acute coronary syndrome who declined participation in conventional CR 179 (19%) 90/89	Six months of home-based cardiac rehabilitation with telemonitoring and coaching based on motivational interviewing. Exercise at moderate intensity for at least 30 min at 5 days/week.	No form of cardiac rehabilitation throughout the study period	Smartphone and connected heartrate belt to measure and record training mode, duration and intensity. Participants contacted by telephone throughout intervention.	Change in VO_2 peak significantly higher in intervention group at 6-months, 1.2 (95%CI 0.2-2.1) $mL/kg^{-1}/min^{-1}$
Maddison et al. (2019) New Zealand [14]	coronary heart disease 162 (16%) 82/80	12-week telerehabilitation. 3x exercise sessions per week with encouragement to be active ≥5 days per week. Prescribed session duration and intensity level ranged from 30 to 60 min at 40%–65% heart rate reserve. Intensity level was adjusted to optimise physiological adaptation	12-weeks of centre-based supervised exercise. 8-12-week program of 2-3x per week 60-minute sessions with 30–45 min of moderate-vigorous intensity aerobic exercise guidelines for exercise in cardiac patients	Smartphone, chest-worn wearable sensor and bespoke app. Exercise parameters and single-lead ECG monitored in real-time and allow direct feedback *via* participants' smartphone (alerts, messages or telephone calls).	No between group difference in $V{\cdot}O_2$max at 12 weeks. 0.51 (−0.97 to 1.98) mL/kg/min ($p > 0.05$)
Varnfield et al. (2014) Australia [15]	post-MI patients referred to CR *120 (10%) 60/60*	6-week home-based CR and remote monitoring. Exercise targets were at least 30 min of moderate activity (Borg's scale of 11–13) on most days of the week with walking as the main exercise mode.	6-week traditional centre-based program. 2x supervised exercise and 1-h educational sessions per week. Cardiovascular and strengthening circuit-based exercise programme of light (6–10) to moderate (11–13) intensity according to Borg's scale.	Smartphone for monitoring, and delivery of content to participants *via* text messages and preinstalled audio and video files. Bespoke web portal.	No between group difference in 6-min walk test at 6-weeks. −10.19 m (−35.0 to 14.63) $p = 0.4$
Oerkild et al. (2012) Denmark [22]	elderly patients who declined participation in centre-based CR 40 (42%) 21/19	2x two home visits by a physiotherapist in a 6-week interval to creating a training programme that could be performed at home and in local surroundings. 30 min exercise/day at a frequency of 6 days/ week at an intensity of 11–13 on the Borg scale.	Non-rehabilitation control group – no active exercise rehabilitation intervention	Telephone monitoring	No between group difference in 6-min walk test at 3-months, 26.2 m (−24.1 to 76.5) $p > 0.05$, or at 12-months, −4.0 m (−56.8 to 48.8), $p > 0.05$.
Noites et al. (2020) Portugal[24]	myocardial infarction 32 (22%) 16/16	8-week home-based CR. 3x weekly aerobic and resistance-based exercise sessions of 70-85-minute duration at moderate intensity (Borg 11-13)	No exercise intervention. Isolated health education sessions	Accelerometer, text messages and phone calls	Greater peak oxygen uptake (ml/min) at 8 weeks in the interventions group ($p = 0.02$)

(*Continued*)

Table 1. Continued.

Author (year of publication) Region trial conducted	Clinical population n (% female) n, Intervention/ control	Trial Intervention	Trial Control	Technology employed	Cardiovascular outcomes and between group differences
Arthur et al. (2002) Canada [17]	low risk post-CABG 242 (19%) 120/122	6-month home-based program as per ASCM guidance 5x weekly. 60-minute sessions (40 min aerobic exercise), intensity set at 60% VO2 peak.	6-month hospital-based program. Supervised exercise sessions 3x per week for 6 months. 60-minute sessions (40 min aerobic exercise), intensity set at 60% VO2 peak.	Telephone monitoring	No difference between groups in Peak VO_2 ($p > 0.05$).
Kraal et al. (2017) Netherland [17]s	acute coronary syndrome 90 (11%) 45/45	3-months home based training (2x week). 3x supervised sessions in hospital outpatients followed by home exercise.45–60 min sessions, based on continuous training with an intensity of 70–85% of the maximal heart rate (HR_{max}).	3-months centre-based group training (2x week). 45–60 min sessions, based on continuous training with an intensity of 70–85% of the maximal heart rate (HR_{max})	Heart rate monitoring with a chest strap (Garmin FR70) and data recorded *via* a web application, reviewed weekly by patient and therapist.	Noeferenn group difference in Peak VO_2 at 3-months $p = 0.25$, or 12 months ($p = 0.89$)
Lear et al. (2014) Canada [18]	Low or moderate risk patients admitted to remote centres for acute coronary syndrome or revascularization procedures 78 (15%) 38/40	4-month virtual CR program delivered *via* the internet 'designed to mimic hospital-based CR'. Scheduled one-on-one chat sessions with nurse, exercise specialist and dietitian (3× each per week), weekly interactive slide education sessions. Participants were asked to wear their heart rate monitors when exercising and upload their exercise data at least twice per week.	Usual care. Participants were given simple guidelines for safe exercising and healthy eating habits and a list of Internet-based resource	Web directed intervention, with embedded 1-1 chat facility. Heartrate monitor	Greater increase in maximal treadmill stress test time at 4-months. 45.7 s (95% confidence interval, 1.04–90.48) $p = 0.045$
Yudi et al. (2021) Australia [16]	acute coronary syndrome 206 (13%) 103/103	Usual care traditional cardiac rehabilitation with an adjunctive smartphone-based cardiac rehabilitation program	Usual care traditional cardiac rehabilitation including standard exercise rehabilitation	Smart phone delivered intervention. Exercise rehabilitation and lifestyle education interventions	Greater change in 6-min walk test at 8-weeks (117 m vs. 91 m; $p = 0.02$)
Fang et al. (2019) China [23]	low-risk patients after percutaneous coronary intervention (PCI) 80 (34%) 40/40	Paper-based CHD educational booklets plus 6-week intervention of outdoor walking/jogging exercise at least 3x per week. 2x home visits by a physical therapist to facilitate	Paper-based CHD educational booklets and biweekly outpatient review	Remote heart rate monitoring with a chest strap and web portal & smartphone app	Greater change in 6-min walk test at 6 weeks (48 m vs. 35 m; $p = 0.006$)
Brouwers et al. 2021 the Netherlands [21]	Coronary artery disease 300 (11%) 153/147	6x supervised outpatient sessions followed by home based rehabilitation. Training parameters set by an algorithm, variable duration and number of sessions.	Group-based outpatient exercise rehabilitation. Training parameters set by an algorithm, variable duration and number of sessions.	Wearable heart rate monitor and accelerometer. Web application to collect data and weekly video consultations	No between group difference in physical activity level at 12 months, using a population-specific model ($p = 0.73$)

the procedures, activities, and/or processes used in the intervention". Further incomplete reporting as to "who provided the intervention?" is also a glaring omission in the CR context, as this impacts on service delivery. Whether a doctor, physiotherapist, specialist nurse or exercise professional was involved in content delivery was opaque in 5 of 12 trials, which raises questions as to safety and also staffing/cost implications when considering translating the trial findings into practice. Modification of the intervention was the least well-reported item, considered in only 2 of 12 trial reports. It may be that the included studies did not modify their interventions, and therefore did not report "something that didn't happen"; however, this question is included in the TIDieR checklist due to the importance of delivering as per the pre-trial protocol, and

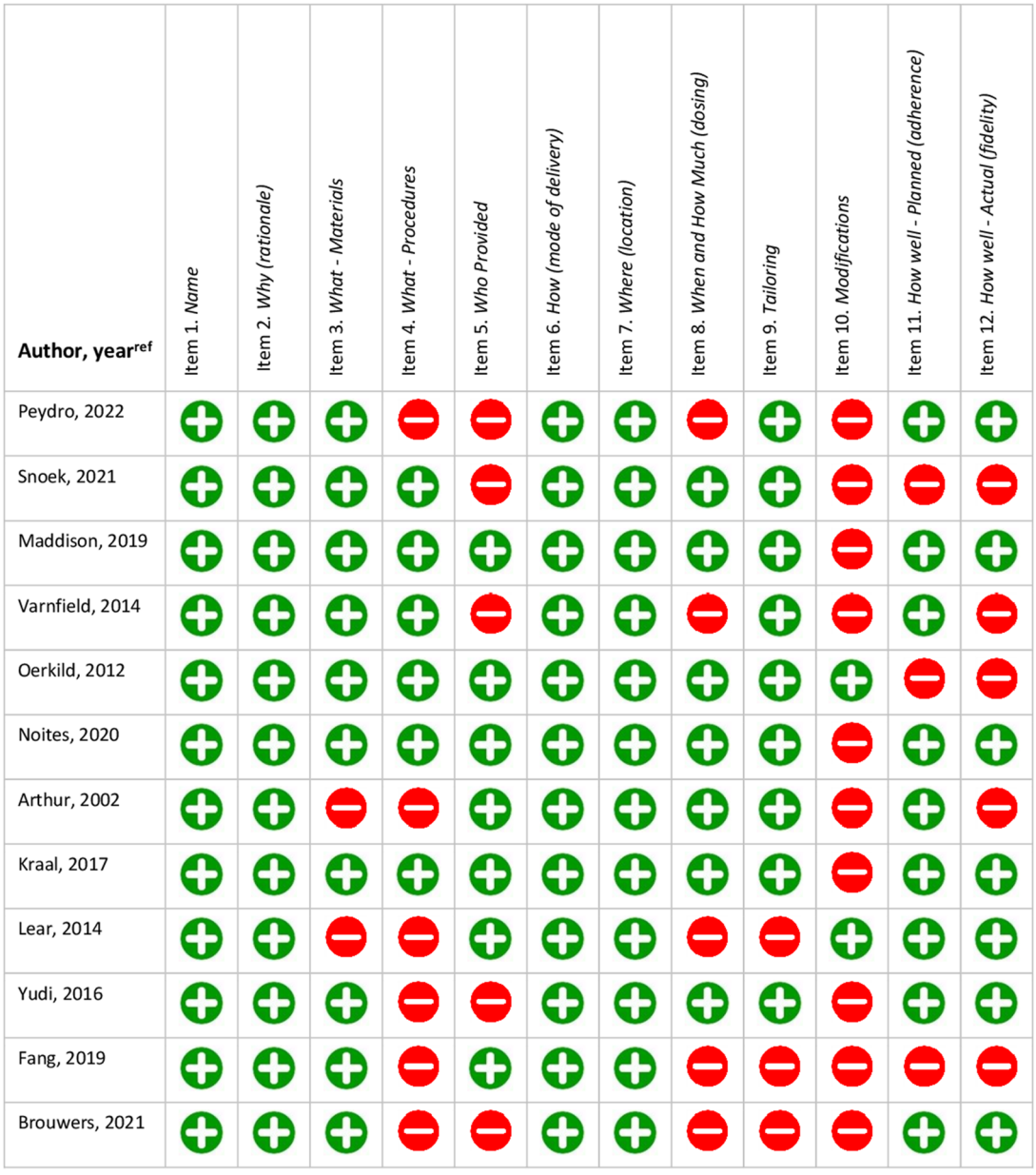

Figure 2. TIDieR reporting by included study.

trialists must carefully consider this when documenting the outcome of their studies.

These reporting failings manifestly influence the reproducibility of the work; however, whether they compromise the validity of the findings of the individual trials is harder to ascertain. Brouwers et al. [20] for example is a generally well-reported, high-quality clinical study, but scored poorly on intervention detail as per TIDieR, as the authors basically stated that an algorithm determined the details. The rehabilitation procedures followed in this trial may have been exemplary, but this cannot be determined by the trial report. Though rehabilitation interventions are often complex and individualized, authors must report sufficient detail if research evidence is to translate into clinical practice change. In the case of exercise rehabilitation, factors such as duration and intensity are highly relevant to rehabilitation outcome. Even in individualized programs, the framework and principles by which these parameters were determined can substantially augment the reporting.

Notably, only four TIDieR criteria were reported by all RCTs; the intervention name, rationale, mode of delivery and location of delivery. These simple details form the basis of any introduction to a study report and are thus easily covered, perhaps suggesting an ongoing lack of awareness of the wider reporting guidelines among exercise-rehabilitation trialists. Interestingly we saw no trend of improved TIDieR reporting over time across the included articles, which is consistent with other authors [32,34]. Others have speculated that TIDieR has not been as well disseminated as the well-established CONSORT and PRISMA guidance, and that this may limit usage [34]; however, trialists that utilize the EQUATOR network guidance should be increasingly aware of TIDieR criteria too. Further scrutiny as to this issue in the rehabilitation literature will hopefully encourage enhanced reporting.

Our study is not without limitations, and we acknowledge that though we have performed a through search of the four major databases where CR trial reports are most

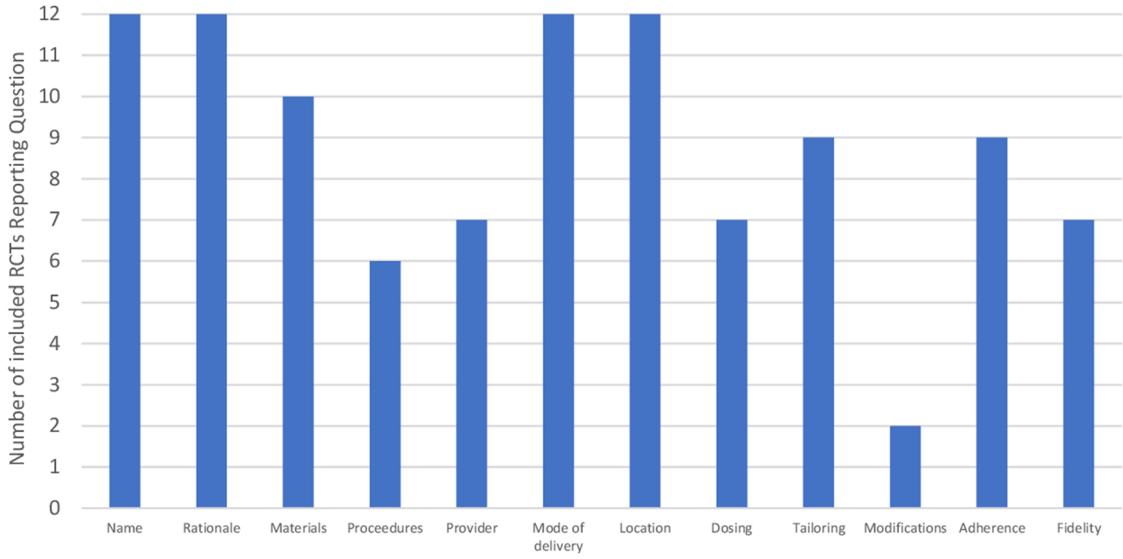

Figure 3. Adherence to TIDieR by checklist question.

likely to be found, this may not be an exhaustive list. Our somewhat niche focus on trials of technology-enabled cardiac rehabilitation may have limited the literature base, and the requirement for English language reports may also affect eligible articles.

Conclusions

Proponents of technology-enabled, remotely delivered cardiac rehabilitation suggest it to be as effective as directly supervised, centre-based care and may be able to substantially improve uptake and adherence to rehabilitation, however, the quality of reporting of these remote interventions in RCTs is insufficient for intervention replication, which has material implications for translation into clinical practice.

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References

[1] WHO. *Cardiovascular diseases*. World Health Organisation. 2022. Retrieved 22/02/2022 from https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1.

[2] Dibben G, Faulkner J, Oldridge N, et al. Exercise-based cardiac rehabilitation for coronary heart disease. Cochrane Database Syst Rev. 2021;11Issue(11):CD001800. Art. No.: doi: 10.1002/14651858.CD001800.pub4.

[3] Turk-Adawi K, Supervia M, Lopez-Jimenez F, et al. Cardiac rehabilitation availability and density around the globe. EClinicalMedicine. 2019;13:31–45. doi: 10.1016/j.eclinm.2019.06.007.

[4] Dalal HM, Doherty P, McDonagh ST, et al. Virtual and in-person cardiac rehabilitation. BMJ. 2021;373:n1270. doi: 10.1136/bmj.n1270.

[5] O'Doherty AF, Humphreys H, Dawkes S, et al. How has technology been used to deliver cardiac rehabilitation during the COVID-19 pandemic? An international cross-sectional survey of healthcare professionals conducted by the BACPR. BMJ Open. 2021;11(4):e046051. doi: 10.1136/bmjopen-2020-046051.

[6] Thomas RJ, Beatty AL, Beckie TM, et al. Home-Based cardiac rehabilitation: a scientific statement from the American Association of Cardiovascular and Pulmonary Rehabilitation, the American Heart Association, and the American College of Cardiology. J Am Coll Cardiol. 2019;74(1):133–153. doi: 10.1016/j.jacc.2019.03.008.

[7] Anderson L, Sharp GA, Norton RJ, et al. Home-based versus centre-based cardiac rehabilitation. Cochrane Database Syst Rev. 2017;6(6):CD007130. Art. No.: Accessed 13 July 2023. doi: 10.1002/14651858.CD007130.pub4.

[8] Lang S, McLelland C, MacDonald D, et al. Do digital interventions increase adherence to home exercise rehabilitation? A systematic review of randomised controlled trials. Arch Physiother. 2022;12(1):24. doi: 10.1186/s40945-022-00148-z.

[9] Cavalheiro AH, Silva Cardoso J, Rocha A, et al. Effectiveness of tele-rehabilitation programs in heart failure: a systematic review and meta-analysis. Health Serv Insights. 2021;14:11786329211021668. doi: 10.1177/11786329211021668.

[10] Ramachandran HJ, Jiang Y, Tam WWS, et al. 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(7):1017–1043. doi: 10.1093/eurjpc/zwab106.

[11] Hoffmann TC, Glasziou PP, Boutron I, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. BMJ. 2014;348(mar07 3):g1687–g1687. doi: 10.1136/bmj.g1687.

[12] Rethlefsen ML, Kirtley S, Waffenschmidt S, et al. PRISMA-S: an extension to the PRISMA statement for reporting litera-

ture searches in systematic reviews. Syst Rev. 2021;10(1):39. doi: 10.1186/s13643-020-01542-z.

[13] NHS. *National Service Framework for Coronary Heart Disease*. 2000. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/198931/National_Service_Framework_for_Coronary_Heart.

[14] Maddison R, Rawstorn JC, Stewart RAH, et al. Effects and costs of real-time cardiac telerehabilitation: randomised controlled non-inferiority trial. Heart. 2019;105(2):122–129. doi: 10.1136/heartjnl-2018-313189.

[15] Varnfield M, Karunanithi M, Lee C, et al. Smartphone-based home care model improved use of cardiac rehabilitation in postmyocardial infarction patients: results from a randomised controlled trial. Heart. 2014;100(22):1770–1779. doi: 10.1136/heartjnl-2014-305783.

[16] Yudi MB, Clark DJ, Tsang D, et al. SMARTphone-based, early cardiac REHABilitation in patients with acute coronary syndromes: a randomized controlled trial. Coron Artery Dis. 2021;32(5):432–440. doi: 10.1097/mca.00000000000009.

[17] Arthur HM, Smith KM, Kodis J, et al. A controlled trial of hospital versus home-based exercise in cardiac patients. Med Sci Sports Exerc. 2002;34(10):1544–1550. doi: 10.1097/00005768-200210000-00003.

[18] Lear SA, Singer J, Banner-Lukaris D, et al. Randomized trial of a virtual cardiac rehabilitation program delivered at a distance via the internet. Circ Cardiovasc Qual Outcomes. 2014;7(6):952–959. doi: 10.1161/CIRCOUTCOMES.114.001230.

[19] Kraal JJ, Van den Akker-Van Marle ME, Abu-Hanna A, et al. 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(12):1260–1273. doi: 10.1177/2047487317710803.

[20] Brouwers RWM, van der Poort EKJ, Kemps HMC, et al. Cost-effectiveness of cardiac telerehabilitation with relapse prevention for the treatment of patients with coronary artery disease in the Netherlands. JAMA Netw Open. 2021;4(12):e2136652. doi: 10.1001/jamanetworkopen.2021.36652.

[21] Peydró E, Sanz Sevilla N, Tuzón Segarra MT, et al. A randomized controlled clinical trial of cardiac telerehabilitation with a prolonged mobile care monitoring strategy after an acute coronary syndrome. Clin Cardiol. 2022;45(1):31–41. 2022 doi: 10.1002/clc.23757.

[22] Oerkild B, Frederiksen M, Hansen JF, et al. Home-based cardiac rehabilitation is an attractive alternative to no cardiac rehabilitation for elderly patients with coronary heart disease: results from a randomised clinical trial. BMJ Open. 2012;2(6):e001820. doi: 10.1136/bmjopen-2012-001820.

[23] Fang J, Huang B, Xu D, et al. Innovative application of a Home -Based and remote sensing cardiac rehabilitation protocol in Chinese patients after percutaneous coronary intervention. Telemed J E Health. 2019;25(4):288–293. doi: 10.1089/tmj.2018.0064.

[24] Noites A, Freitas CP, Pinto J, et al. Effects of a phase IV Home-Based cardiac rehabilitation program on cardiorespiratory fitness and physical activity. Heart Lung Circ. 2017;26(5):455–462. doi: 10.1016/j.hlc.2016.08.004.

[25] Snoek JA, Prescott EI, van der Velde AE, et al. Effectiveness of home-based mobile guided cardiac rehabilitation as alternative strategy for nonparticipation in clinic-based cardiac rehabilitation among elderly patients in Europe: a randomized clinical trial. JAMA Cardiol. 2021;6(4):463–468. doi: 10.1001/jamacardio.2020.5218.

[26] Yamato TP, Maher CG, Saragiotto BT, et al. How completely are physiotherapy interventions described in reports of randomised trials? Physiotherapy. 2016;102(2):121–126. doi: 10.1016/j.physio.2016.03.001.

[27] McEwen D, O'Neil J, Miron-Celis M, et al. Content reporting in post-stroke therapeutic circuit-class exercise programs in randomized control trials. Top Stroke Rehabil. 2019;26(4):281–287. doi: 10.1080/10749357.2019.1591687.

[28] Tew GA, Brabyn S, Cook L, et al. The completeness of intervention descriptions in randomised trials of supervised exercise training in peripheral arterial disease. PLoS One. 2016;11(3):e0150869. doi: 10.1371/journal.pone.0150869.

[29] Burgess LC, Wainwright TW, James KA, et al. The quality of intervention reporting in trials of therapeutic exercise for hip osteoarthritis: a secondary analysis of a systematic review. Trials. 2021;22(1):388. doi: 10.1186/s13063-021-05342-1.

[30] Meneses-Echavez JF, Rodriguez-Prieto I, Elkins M, et al. Analysis of reporting completeness in exercise cancer trials: a systematic review. BMC Med Res Methodol. 2019;19(1):220. doi: 10.1186/s12874-019-0871-0.

[31] Webster RK, Howick J, Hoffmann T, et al. Inadequate description of placebo and sham controls in a systematic review of recent trials. Eur J Clin Invest. 2019;49(11):e13169. doi: 10.1111/eci.13169.

[32] Palmer W, Okonya O, Jellison S, et al. Intervention reporting of clinical trials published in high-impact cardiology journals: effect of the TIDieR checklist and guide. BMJ Evid Based Med. 2021;26(3):91–97. doi: 10.1136/bmjebm-2019-111309.

[33] Vanhees L, Hansen D. Modalities of exercise training in cardiac rehabilitation. In: Pressler A , Niebauer J, editors. Textbook of sports and exercise cardiology. Cham: Springer; 2020. p. 881–896. doi: 10.1109/VCIP53242.2021.9675332.

[34] McCambridge AB, Nasser AM, Mehta P, et al. Has reporting on physical therapy interventions improved in 2 decades? An analysis of 140 trials reporting on 225 interventions. J Orthop Sports Phys Ther. 2021;51(10):503–509. doi: 10.2519/jospt.2021.10642.