Paper Type: Systematic Review

Title: Systematic Review of the Use of Behaviour Change Techniques in Physical Activity eHealth Interventions for People with Cardiovascular Disease

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Abstract

Background: Cardiovascular disease (CVD) is the leading cause of premature death and disability in Europe, accounting for four million deaths per year and costing the EU economy almost €196 billion annually. There is strong evidence to suggest that exercise-based secondary rehabilitation programmes can decrease the mortality risk and increase health among patients with CVD. Theory informed use of behaviour change techniques (BCTs) is important in the design of cardiac rehabilitation programmes aimed at changing cardiovascular risk factors. Electronic health (eHealth), is the use of information and communication technologies (ICT) for health. This emerging area of healthcare has the ability to enhance self-management of chronic disease through making healthcare more accessible, affordable and available to the public. However, evidence-based information on the use of BCTs in eHealth interventions is limited, and particularly so for individuals living with CVD.

Aim: The aim of this systematic review was to assess the application BCTs in eHealth interventions designed to increase physical activity (PA) in CVD populations.

Methods: Seven electronic databases EBSCOhost (MEDLINE, PsycINFO, Academic Search Complete, SPORTDiscus with Full Text, CINAHL Complete), Scopus and Web of Science (Core Collection) were searched. Two authors independently reviewed references using the software package Covidence. The reviewers met to resolve any discrepancies, with a third independent acting as arbitrator when required.

Following this, data was extracted from the papers that met the inclusion criteria. Bias assessment of the studies was carried out using the Cochrane Collaboration's risk of bias tool within Covidence, this was followed by a narrative synthesis.

Results: From the 987 studies identified 14 were included in the review. An additional 9 studies were added following a hand search of review paper references. The average number of BCT's used across the 23 studies was 7.2 (range 1 to 19). The top three most frequently used BCTs included; information about health consequences (78.3%), goal setting (behaviour) (73.9%) and self-monitoring of behaviour (47.8%).

Conclusion: This systematic review is the first to investigate the use of BCTs in physical activity eHealth interventions specifically designed for people with CVD. This research will have clear implications for healthcare, policy and research by outlining the BCTs used in eHealth interventions for chronic illnesses, in particular CVD. Hence, providing clear foundations for further research and developments in the area.

Systematic review registration: PROSPERO CRD42016034157

Keywords: Systematic review, physical activity, behaviour change techniques, eHealth intervention, cardiovascular disease

Introduction

Cardiovascular disease (CVD) is the leading cause of mortality worldwide, accounting for 30% of global death and 48% of deaths in Europe [24]. Cardiac rehabilitation (CR) is used to reduce the impact of CVD and to promote healthy behaviours and active lifestyles for those with CVD [25]. It has been shown to improve physical health and decrease subsequent morbidity and mortality rates in CVD populations [26]. The main modality of cardiac rehabilitation is exercise. Two systematic reviews of exercise-based CR, which included 48 randomised controlled trials, showed a 20% reduction in all-cause mortality and a 27% reduction in cardiac mortality at two to five years [27] [28].

The efficacy of standard cardiac rehabilitation has been extensively reviewed. In terms of mortality rates a systematic review and meta-analysis of 25 randomised controlled trials (n=6111 myocardial infarction patients) showed that those who attended CR had a lower-risk of all-cause mortality than non-attendees (odds ratio 0.74 (0.58 to 0.95)) [29]. In terms of hospital admissions, a Cochrane review of 33 RCTs (n=4740 patients with heart failure, CR reduced the risk of overall hospitalization (relative risk 0.75 (0.62 to 0.92), ARR 7.1%, NNT 15) and hospitalization for heart failure (relative risk 0.61 (0.46 to 0.80), ARR 5.8%, NNT 18) [30]. A US observational study (n=635 coronary heart disease patients) reported improvements in depression, anxiety and hospital scores after CR [31]. Cardiac rehabilitation has also been found to improve psychological wellbeing and improvement in quality of life. One of the most significant benefits of cardiac rehabilitation exercise training to participants is the improvement in aerobic capacity and cardio-respiratory fitness [32].

Even though CR has been shown to be effective, adherence to these programmes is generally suboptimal. Participation rates in CR are documented at less than 50% worldwide [33]. Results from a Cochrane systematic review revealed that common barriers to adherence to CR programmes included accessibility and parking at local hospitals, a dislike of group environments and work or domestic commitments [26]. In 2012, a HEART journal editorial concluded that CR should not only focus on content, such as coronary heart disease (CHD) risk factor modification and medication adherence but should also focus on the delivery mechanisms, offering a range of different delivery methods for people according to their preferences and needs, potentially addressing the issue of low levels of participation [34]. The delivery of CR to date has largely been centre-based, either in hospitals or community centres. However, in more recent times there has been a shift toward a more home-based model of care. A systematic review by Dalal and colleagues [26] found that both home and center based forms of CR are equally effective in improving clinical and health related quality of life outcomes in patients with cardiovascular disease, suggesting the further provision of additional evidence-based home CR programmes. A Cochrane review found that home-based interventions may be superior in terms of adherence to exercise, especially in the long term [35]. This would ensure that patients are given the choice of participating in a

more traditional supervised center-based programme or a home-based programme, based on their personal preference.

The emerging area of electronic health (eHealth), defined as the use of information and communication technologies (ICT) for health [36] may provide this alternative home-based delivery method. Interventions that encompass ICT (e.g. internet- and mobile based communications, wearable monitors etc.) enable the efficient delivery of educational resources, individually tailored health and wellness programs as well as time-unlimited feedback, coaching and support [37]. Technology solutions for physical activity uptake and monitoring are being undertaken as a new mode of facilitating behaviour change and may impact the current delivery of cardiac rehabilitation [38]. Tele-rehabilitation solutions refer to the use of Information and Communication Technologies (ICT) to provide rehabilitation services to people. Literature in this area for cardiac patients indicates that such interventions are feasible and effective when compared to conventional centre-based CR [39].

eHealth interventions have been showing promising results in cardiac rehabilitation, supporting behaviour change, clinical improvement and improved social functioning. In 2013, Beatty and Colleagues [40] conducted a review of mobile interventions for cardiac rehabiitation, identifying only 3 studies for inclusion. More recently the interest in e- and mHealth has risen dramaticaally, indicating the increased focus in this field over recent years. Buys and colleagues [38] investigated the interest among cardiac patients in technology enabled cardiovascular rehabilitation. Of the 298 patient (77% male; mean age 61.7 $\pm$ 14.5 years) questionnaires included in the analysis, 97% had a mobile phone and 91% used the internet. Physical activity monitoring was reported by 12% of the respondents. Overall cardiac patients showed high interest in CR support through the internet (77%) and mobile phones (68%). These findings suggest that CVD patients show an interest in technology enabled home-based CR, potentially allowing exercise based rehabilitation programmes be more effective by making them more accessible, personalised and more interactive with patients.

BCTs are integral in the design of complex health service interventions, such as cardiac rehabilitation. A BCT is defined as “an observable, replicable and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour; that is, a technique is proposed to be an ‘active ingredient’” [41]. The Medical Research Council (MRC) guidelines recommend the application of behaviour change theory within complex health service interventions to allow for a theoretical understanding of behaviour change [42]. The National Institute of Health and Care Excellence [43] guidelines on individual-level behaviour change interventions aimed at changing health-damaging behaviours such as unhealthy diet, physical inactivity, excessive alcohol consumption, unsafe sex and smoking, recommend the use of evidence-based BCTs, which have been proven to be effective at changing behavior, such as goals and planning, feedback and monitoring and social support. Despite this

guidance, few interventions pay close attention to the behaviour change theory and techniques used to design their interventions. In particular, the poor description of interventions in research protocols and published reports presents a barrier for future design of complex interventions [44], as it is difficult to identify the active, effective components of the intervention [41]. The proliferation of eHealth interventions requires the coding of such interventions to facilitate future research to compare accurately across interventions. With that in mind, this systematic review aims to identify the key behaviour change techniques applied in eHealth physical activity interventions for adults with cardiovascular disease.

Methods

This systematic review is reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidance. The inclusion criteria for studies were as follows; human randomised and quasi-randomised controlled trials, published and unpublished, of physical activity eHealth interventions for adults (≥18 years old) clinically diagnosed with cardiovascular disease. Studies were included if the main intervention component was delivered via a computer, smartphone, tablet or phone (e.g. mobile phone App, emails, text messages, phone calls) with the primary or secondary aim of increasing the physical activity level of the user. The interventions could be delivered to groups or individuals. The inclusion criteria was kept quite broad in order to identify as many studies as possible which had physical activity as a primary or secondary outcome, as well as studies which had PA as a component of the intervention.

The Behaviour Change Taxonomy v1 was used to identify the specific BCT's used within the included studies [41]. Two researchers coded for the BCTs using the taxonomy.

Outcome measures

A description of the BCTs and their frequency of use in the 23 eHealth interventions reviewed were classified using Michie's taxonomy. Due to the heterogeneous nature of the studies, differing in physical activity outcome measures and time-points we were unable to carry out a meta-analysis examining the effectiveness of the BCTs in relation to the physical activity outcomes.

Search methods for the identification of studies

Seven electronic databases were searched, including MEDLINE (via EbscoHost, 2000 to 2016), PsycINFO (via EbscoHost, 2000 to 2016), Academic Search Complete (via EbscoHost, 2000 to 2016), SPORTDiscus (via EbscoHost, 2000 to 2016), CINAHL Complete (via EbscoHost, 2000 to 2016), Scopus (2000 to 2016) and Web of Science (Core Collection) (2000 to 2016).

The search was restricted to studies published in English between 2000 and 2016. The search strategy used keywords relating to physical activity, eHealth interventions, cardiovascular disease and adults, as well as appropriate synonyms. Boolean operators were used to expand, exclude or join keywords in the search, using the terms “AND” and “OR”. In all databases, the searches were limited to the fields of abstract and title only. The search strategy for all databases is illustrated in the Additional File 1.

Selection of studies

Figure 1 shows the PRISMA flow diagram of reviewed and included studies. One researcher conducted the database search. All articles identified following the database search were then uploaded to the online systematic review software package “Covidence”. Firstly, a title and abstract review of all studies was completed independently by two authors. Any disagreements were discussed until a consensus was reached or a third reviewer helped to resolve the discrepancy. A record was kept of all the articles excluded and the reason for exclusion via Covidence. Secondly, all articles that met the inclusion criteria went through a full text screening process by the two authors independently. Again, any disagreements between the authors on the eligibility of the studies were reviewed by a third author. Additional studies were also identified for inclusion by reviewing the reference lists of review papers through a hand search.

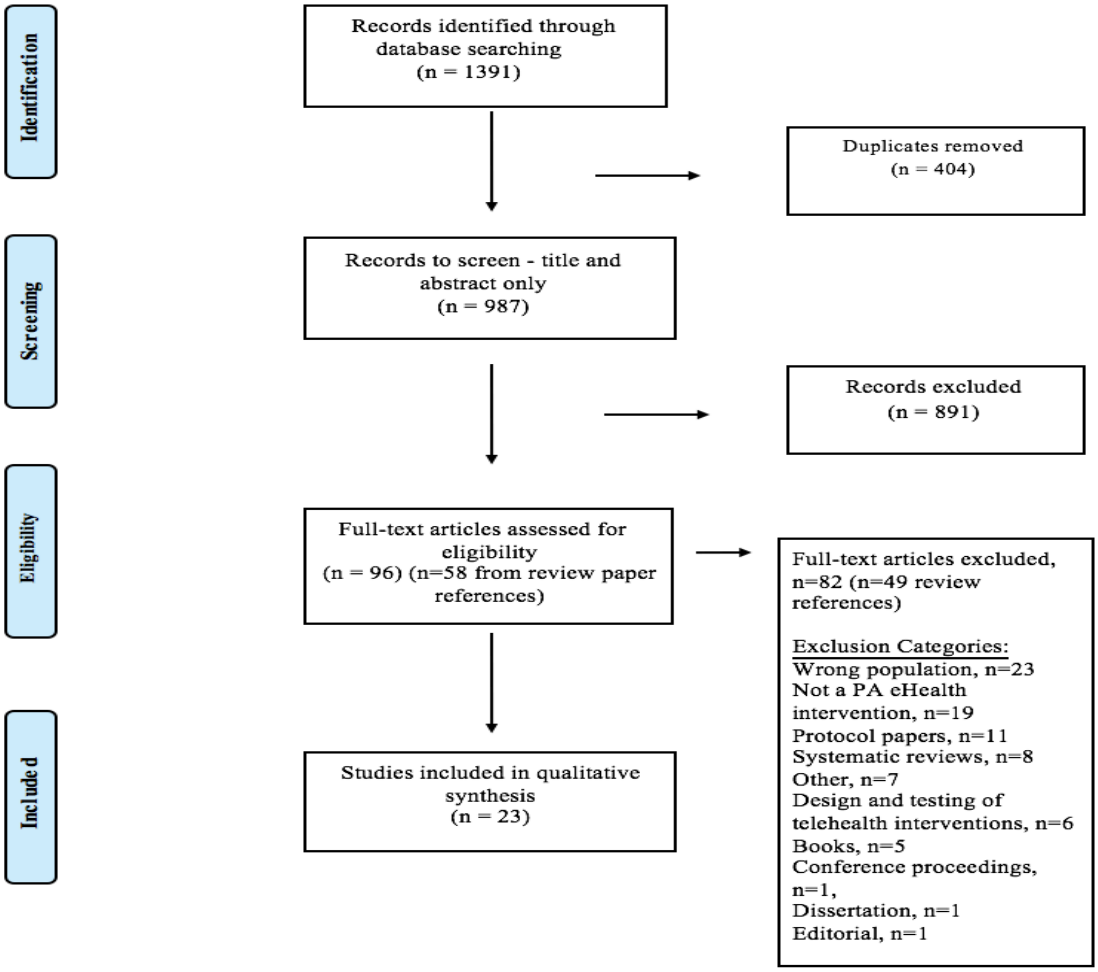

Figure 1. PRISMA flow diagram of reviewed and included studies

Data extraction

Data from the studies were extracted independently by two review authors using a data extraction template. Data extracted from the articles included study title, authors, country, year, patient group (sample size), inclusion criteria, study design, technology involvement, assessment, intervention details, outcomes, theory involved, BCTs identified and results. No blinding to study author, institution or journal occurred during the study screening process.

If multiple publications of the same study were identified, the team would try to extract and combine all the available data and where there was doubt, the original publication would be given priority. If data seemed to be missing from a study, we tried to obtain this through correspondence with the study authors. The review team resolved any disagreements regarding study eligibility through group discussion.

Assessment of risk bias

Two reviewers assessed each study for risk of bias (high, low or unclear) using the Cochrane risk of bias tool [45]. A third review author acted as arbitrator if necessary.

The results of the risk of bias assessment were then exported to RevMan to create a visual representation of the publication bias (see Figure 2).

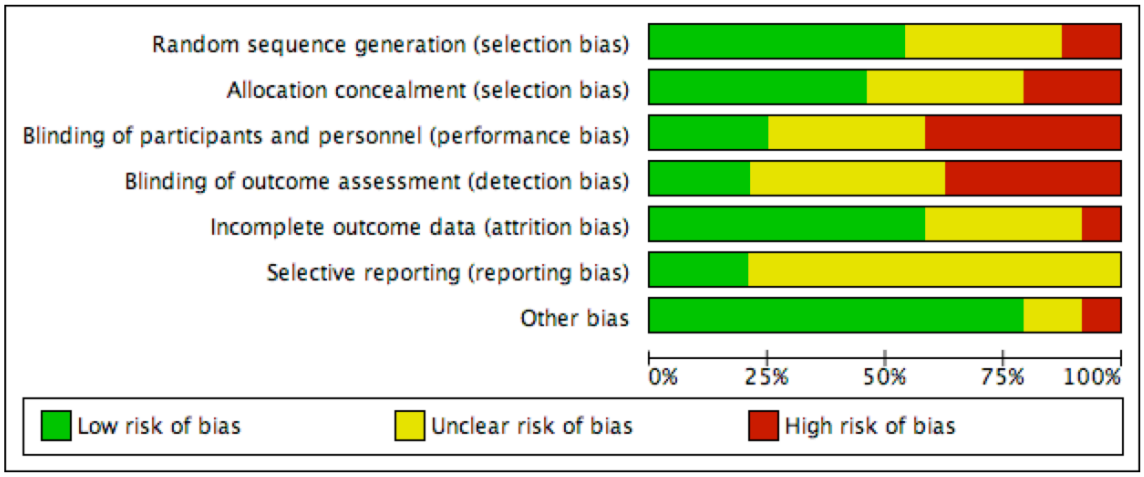

Figure 2: Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Assessing for heterogeneity

Diversity across the studies was assessed qualitatively in terms of eHealth intervention, patient characteristics and outcome measures.

Data synthesis

Following the extraction of data from the studies, careful consideration was given to the appropriateness of conducting a meta-analysis. As the studies were too heterogeneous to combine statistically, the data were synthesised qualitatively.

Behaviour Change Techniques (BCTs)

To gain an understanding of the types of behaviour change techniques used in physical activity eHealth interventions in this patient population, two authors screened the included articles' and coded the behaviour change techniques (BCTs) used in each study using Michie's BCT taxonomy [41].

Results

The search criteria returned 1391 articles through databases searching. A total of 404 duplicates were removed, leaving 987 articles to screen. The articles title and abstracts were then screened by two reviewers, resulting in 891 records excluded for not meeting the inclusion criteria. The authors reviewed the full text of 96 studies, identifying 14 studies for inclusion in this review. From a hand search of review papers references an additional 58 studies were identified as potentially eligible. Following a full text review

of these papers, 9 studies were included in the review. Therefore, a total of 23 articles were included in the qualitative synthesis.

Study characteristics

Table 1 provides an overview of the included studies and the physical activity results. Of the 23 studies included, 14 comprised an internet/web-based programme and/or smartphone intervention [2-3, 6, 8, 10-11, 14, 16-19, 21-23], 3 were telephone interventions [1, 12-13], 2 used a telehealth device [4] [5], and 2 consisted of a form of telemonitoring [15] [20]. Single studies consisting of videoconferencing [9] and of virtual reality wraparound screens [7] were also found. Of the 20 studies with a control group, 17 involved 'usual care' as the control. Usual care predominately pertained to receiving standard cardiac rehabilitation services [1,4-11, 13-15, 17, 19,21-23]. Eight studies were carried out in Europe [2, 3, 10-11, 13, 16, 18, 20], while seven of the studies were conducted in North/South America [1, 4-5, 14, 18, 21, 23]. Three studies apiece were conducted in Australia [6, 12, 22] and New Zealand [8-9, 17] and two studies were conducted in Asia [6,15].

The majority of participants were recruited from hospitals/medical centres [1-8, 10, 12-14, 16, 18-23]. One study recruited participants from a general practitioner (GP) coronary heart disease (CHD) registry [16], while another recruited from a CR referral list [12]. Tomita and colleagues [21] recruited participants from three hospitals and two health insurance companies. One study recruited participants from primary and community health services [22]. Outcomes were assessed from 3 weeks [5] to 16 months [13], with the average end-point across the 23 studies at 4.5 months.

-Insert Table 1 approximately here-

Behavioural change techniques

Only 2 out of the 23 studies explicitly mentioned the BCTs applied [8] [10]. From the other studies, two reviewers coded the BCTs from the program description. Table 2 outlines the number of BCTs used in each study as well a comprehensive list of the techniques used. The average number of BCTs employed in the included studies was 7.2 (Range 1-14). The top three most frequently used BCTs were identified as information about health consequences (78.3%), goal setting (behaviour) (73.9%) and self-monitoring of behaviour (47.8%) (See Table 2). The Text4Heart study conducted by Dale and colleagues [8] employed the most BCT's out of all the articles, using 14. These were goal setting (behaviour), problem solving, review outcome goals, feedback on behaviour, self-monitoring of behaviour, social support (unspecified), instruction on how to perform the behaviour, information about health consequences, demonstration of the behaviour, social comparison, prompts/cues, graded tasks, credible source and reduce negative emotions. A study by Barnason and colleagues [5] used the least amount of BCTs of the 23 studies included in the review, employing just one BCT, graded tasks.

The most common BCT group used in the 23 included studies was feedback and monitoring, while the second most common group was goals and planning. This was followed by social support. Four groups did not appear in any of the 23 included studies; identity, scheduled consequences, self-belief and covert learning.

-Insert Table 2 approximately here-

Table 3 outlines the frequency of use of the BCTs across the 23 studies, the BCT taxonomy group and an example of how a BCT was incorporated into a study. Only two BCTs were used in over 70% of the studies, these were 5.1 information about health consequences (78.3%) and 1.1 goal setting (behaviour) (73.9%). A further 4 BCTs were used in over 40% of the studies, these include; 2.2 feedback on behaviour (43.5%), 2.3 self-monitoring of behaviour (47.8%), 3.2 social support (practical) (47.8%) and 4.1 instruction on how to perform the behaviour (43.5%). Several BCTs including, 10.3 non-specific reward, 12.1 restructuring the physical environment, 12.5 adding objects to the environment, 11.1 pharmacological support, 6.1 demonstration of the behaviour, 6.2 social comparison, 1.7 review outcome goals, 10.4 social reward and 1.8 behavioural contract were only used in one study (See Table 3 for more details).

-Insert Table 3 approximately here-

Behaviour Change Techniques Linked to Improved Physical Activity Outcomes

Eight of the 15 interventions that had PA as an outcome measure reported statistically significant improvements in physical activity between the experimental and control groups. Goal setting (behaviour) and information about health consequences were the most frequently used BCTs across the eight studies (n=6 each). This was followed by feedback on behaviour and instruction on how to perform the behaviour, which were incorporated in 5 studies each. The following BCT's were also included in the interventions which had an improved PA outcome at the final endpoint; self-monitoring of behaviour, social support (practical), social support (unspecified), credible source, problem solving, review behaviour goals, social support (emotional), prompts/cues, graded tasks, reduce negative emotions, action planning, self-monitoring of outcomes of behaviour, biofeedback, feedback on outcome(s) of behaviour, social reward and pharmacological support (See table 4).

Table 4: Frequency of behavioural change techniques (BCTs) used in studies with improved PA outcome

BCT label	Total number of studies n=8 N (%)
1.1 Goal setting (behaviour)	6 (75)
5.1 Information about health consequences	6 (75)
2.2 Feedback on behaviour	5 (62.5)
4.1 Instruction on how to perform the behaviour	5 (62.5)
2.3 Self-monitoring of behaviour	4 (50)
3.2 Social support (practical)	4 (50)
3.1 Social support (unspecified)	3 (37.5)
9.1 Credible source	3 (37.5)
1.2 Problem solving	2 (25)
1.5 Review behaviour goals	2 (25)
3.3 Social support (emotional)	2 (25)
7.1 Prompts/cues	2 (25)
8.7 Graded tasks	2 (25)
11.2 Reduce negative emotions	2 (25)
1.4 Action planning	1 (12.5)

2.4 Self-monitoring of outcomes of behaviour	1 (12.5)
2.6 Biofeedback	1 (12.5)
2.7 Feedback on outcome(s) of behaviour	1 (12.5)
10.4 Social reward	1 (12.5)
11.1 Pharmacological support	1 (12.5)
1.3 Goal setting (outcome)	0 (0)
1.7 Review outcome goals	0 (0)
1.8 Behavioural contract	0 (0)
2.1 Monitoring of behaviour by others without feedback	0 (0)
2.5 Monitoring of outcomes of behaviour without feedback	0 (0)
6.1 Demonstration of the behaviour	0 (0)
6.2 Social comparison	0 (0)
10.3 Non-specific reward	0 (0)
12.1 Restructuring the physical environment	0 (0)
12.5 Adding objects to the environment	0 (0)

It is worth noting that those interventions that did not did demonstrate a significant increase in PA (n= 5) were on par with the level achieved in standard CR, as no significant differences between the control and experimental groups were found. This is an important finding as it highlights the fact that the eHealth interventions were on par with or were significantly better at improving PA levels of cardiac patients when compared to standard cardiac services. This emphasizes the potential of eHealth interventions in a cardiac rehabilitation setting.

To further examine the efficacy of the individual BCTs the interventions were grouped into four groups depending on whether physical activity was measured objectively or subjectively and whether there was a difference between experimental and control groups. Once the interventions were grouped we sought to examine if there were any common BCTs used across the studies (See table 5). This task allowed us to examine if there were any similarities between the interventions in terms of the BCTs they

employed. Objective and self-report studies with no difference between experimental and control groups were the only groups with similarities in the BCTs they employed. Social support (practical) and information and health consequences were employed in all self-report studies where there was no PA difference between the experimental and control groups. Goal setting (behaviour) and feedback on behaviour were employed in all PA objectively measured intervention where no significant difference was found between groups at the final endpoint. However, there were no similarities in the BCTs used across all the effective interventions, regardless of whether PA was measured objectively or subjectively. Furthermore, the average number of BCTs used across significant interventions did not differ, as studies that increased PA versus those that did not increase PA employed on average 7 BCTs.

-Insert Table 5 approximately here-

Discussion

Summary

This systematic review consisted of 23 studies reviewing the use of BCTs in physical activity eHealth interventions for adults with cardiovascular disease. To our knowledge, this is the first review that aimed to identify the use of Michie's behaviour change taxonomy in physical activity eHealth intervention studies among this population. The findings of the review indicate that an average of 7.2 BCTs were employed in the 23 studies. Information about health consequences was the most frequently used technique, with 78.3% of studies incorporating this technique into their intervention. This was followed closely by goal setting (behaviour), which was used in 73.9% of the studies, with self-monitoring of behaviour employed in 47.8% of the studies.

Although Michie's behaviour change technique taxonomy is made up of 93 different techniques, the maximum amount of techniques used in a single intervention was 14 [8]. These were goal setting (behaviour), problem solving, review outcome goals, feedback on behaviour, self-monitoring of behaviour, social support (unspecified), instruction on how to perform the behaviour, information about health consequences, demonstration of the behaviour, social comparison, prompts/cues, graded tasks, credible source and reduce negative emotions. The minimum number of techniques used in a study was one; graded tasks [5]. A failing of the studies included in this review was the poor description of the intervention components. Only two papers in the review specifically mentioned the behaviour change techniques incorporated in their interventions [8] [10]. However, even though the paper by Devi and colleagues [10] listed the BCT's used, it failed to link the BCT's used to the intervention functions or components. In the study by Dale [8] the researchers provided only examples of text messages linked to BCTs. Neither study gave a full account of the BCTs used in their studies and how these were linked to the intervention components. This finding is in line with previous research, where reviews of nearly 1,000 behaviour change outcome studies found that interventions were fully and accurately were described in only 5% to 30% of experimental studies [46] [47] [48] [49]. Overall this lack of robust and detailed information on the intervention functions provide a significant barrier to better understanding the effects and mechanisms of behaviour change interventions, to inform the development of more effective interventions in the future [39].

Another key issue relating to the poor description of behaviour change interventions is the inconsistent use of terminology. This variation in terminology used makes the coding of the techniques used even more difficult when reviewing behaviour change interventions. For example, social support (unspecified) was coded for in 41.67% of the studies included in the review by the reviewers. Terminology varied across the studies where social support was coded, for example, one study used a social reinforcement network [3], another incorporated mentors into their intervention [22], while another study involved tutorials in their intervention [19]. The reviewers coded these examples as social support (unspecified) however, this BCT was not specifically mentioned in any

of the studies. Therefore, there is a need to have consistent terminology and sufficient information on intervention components to allow for the replication of interventions that have been found to be effective. The lack of such information appears to be particularly problematic in behavioural interventions rather than for pharmacological ones [44]. In a workshop 26 multi-disciplinary researchers were presented with behavioural or pharmacological intervention protocols and were asked if the protocol provided sufficient information so that the study could be replicated in a practice setting. The researchers were less confident that they could replicate the behavioural interventions compared to the pharmacological interventions ($t = 6.45$, $p < 0.0001$) and concluded they would need more information to replication the behavioural interventions ($U = 35.5$, $p=0.022$) [50].

This review provides new and important information regarding the use of behaviour change techniques in eHealth physical activity for adults with CVD, highlighting the frequent use of the following BCT's; information about health consequences, goal setting (behaviour), self-monitoring of behaviour. However, it is clear that more robust and comprehensive interventions are needed, which systematically and coherently detail the behaviour change techniques used in the interventions. Identifying the active ingredients of the interventions will enable researchers to examine the effectiveness of these key intervention components, ensuring that the most effective BCTs are used regarding eHealth physical activity interventions for adults with cardiovascular disease.

Strengths and Limitations

A major strength of this review was the authors attempt to identify all relevant studies by using a comprehensive search strategy and multiple databases. The authors' also hand searched review paper references to identify any additional studies which may have been relevant to the review. All articles identified following the database search were then uploaded to the online systematic review software package "Covidence". This allowed for a systematic and comprehensive approach to screening the articles and coding the reasons for exclusion. This software also enabled the screening for risk of bias in a simple and efficient way. From this, a visual representation of the publication bias was produced using RevMan.

A limitation of this review was the wide variability among the studies included, with study designs ranging from randomised controlled trials, to feasibility studies and pilot trials. However, it was necessary to include all studies and not just RCTs to identify as many physical activity eHealth interventions as possible. There was also a lack of consistency in the measurement of physical activity across the studies, from subjective to objective assessments. The follow-up duration also varied significantly from 3 weeks to 16 months. This meant it was impossible to pool the results in a meta-analysis.

Many studies measured the physical fitness of their participants, as opposed to their physical activity levels. Although all the interventions had a physical activity/exercise component to their eHealth intervention, some studies did not directly measure the physical activity level of participants. We can therefore only infer from the studies that by increasing physical activity behaviour that the physical fitness outcome improved. This inference of a causal relationship between physical activity and physical fitness is a limitation to these studies. Another limitation is the variety of methods used to measure physical activity, meaning that comparison between studies is challenging and therefore determining the impact of specific BCTs is impossible.

Implications for research and practice

This systematic review highlights the need for more robust and comprehensive eHealth physical activity interventions for adults with CVD. While the most frequently used BCT's are identified, it is worth noting that the majority of studies did not specifically detail the active ingredients of their interventions. Further work is also needed to determine what is the most appropriate measurement of physical activity among this population so that interventions use the best subjective and/or objective measurements ensuring comparisons can be easily drawn across studies. The review also highlights the importance of identifying the behaviour change techniques used within a study and their link to the intervention components in order to understand the ingredients that bring about the desired behaviour change. It is only by identifying these mechanisms of change that we can understand why an intervention was found to be effective or not.

Authors' contributions

OD ran the keyword search in the chosen databases and reviewed all articles for inclusion and exclusion. OD drafted in large part the first version of the manuscript. DW was the second reviewer who reviewed the articles for inclusion and exclusion in the review. DW and OD independently extracted data from the final papers for inclusion. CW was the third reviewer if any discrepancies occurred between OD and DW in the review and data extraction processes. CW, DW and BF revised and provided feedback on the drafts on the manuscript. KW and NOC also provided feedback on the manuscript. All authors have read and approved the final version of the manuscript.

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Conflicts of interest

None declared.

Abbreviations

BCTs: Behaviour change techniques

CVD: Cardiovascular disease
CR: Cardiac rehabilitation
CHD: Coronary heart disease
eHealth: Electronic health
ICT: Information and communication technologies
PA: Physical activity
SFI: Science Foundation Ireland

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