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Impact of virtual reality on cardiac rehabilitation-related anxiety: a protocol for systematic review and meta-analysis

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To cite: Shahab A, Misquith C, Bashir Z. Impact of virtual reality on cardiac rehabilitation-related anxiety: a protocol for systematic review and meta-analysis. *Open Heart* 2022;**9**:e002094. doi:10.1136/openhrt-2022-002094

Received 20 July 2022
Accepted 13 October 2022

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ABSTRACT

Introduction Cardiac rehabilitation has proven beneficial in cardiovascular patients and is strongly recommended for secondary prevention after a coronary event. However, overall utilisation of cardiac rehabilitation is often low. The addition of novel methods of rehabilitation may increase overall compliance with cardiac rehabilitation. The use of virtual reality (VR) has been adopted in a variety of therapeutic ways such as physical rehabilitation in neurological diseases, rehabilitation for various psychiatric illnesses and postcancer rehabilitation in breast cancer survivors. In our meta-analysis, we wish to assess whether the addition of VR (fully immersive or non-immersive) leads to an improvement in anxiety and functional capacity compared with standard cardiac rehabilitation at any phase of the rehabilitation process.

Method and analysis This systematic review and meta-analysis protocol was structured according to the published Preferred Reporting for Systematic Review and Meta-analysis—Protocol guidelines. We will devise a search strategy to use online databases to search for the randomised controlled trials. Inclusion criteria and exclusion criteria will be defined. The articles will be reviewed by two independent reviewers and any conflict will be adjudicated through discussion. The bias in the selected studies will be assessed using Cochrane risk-of-bias tool for randomised trials (RoB 2). The outcome of interest will be anxiety and functional capacity. Effect estimates will be reported as standardised mean difference with 95% CI. Fixed effect model will be used if I^2 <60%, otherwise random effect model will be used to estimate the effect size.

Ethics and dissemination There will be no direct involvement of the patient or the public in the conception, design, data collection and analysis of this systematic review and meta-analysis. Results of this systematic review and meta-analysis will be disseminated via journal articles. In accordance with the guidelines, our systematic review protocol is prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO) on 07 August 2022.

PROSPERO ID CRD 42022342736.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Prior studies have shown an improvement in anxiety related to cardiac catheterisation with the addition of virtual reality (VR) technology. VR-assisted aerobic exercise has been compared to conventional cardiac rehabilitation. However, there were limitations in the review due to the number of studies included and the patient demographics. Additionally, VR-assisted relaxation exercises were not studied in relation to improvement in rehabilitation-related anxiety.

WHAT THIS STUDY ADDS

⇒ This review will focus on the effects of VR technology on anxiety and functional capacity during cardiac rehabilitation. It will evaluate both VR-assisted aerobic exercises and VR-assisted relaxation exercises. In addition, we plan to include both fully immersive and non-immersive VR technology and demonstrate their effects on anxiety and functional capacity separately which has not been studied previously.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This review will study the effects of VR on cardiac rehabilitation related anxiety and functional capacity. It will add to the growing body evidence for utilising novel techniques to improve compliance with cardiac rehabilitation. It will promote further research on adopting novel methods for making the rehabilitation experience more enjoyable and effective for the patients.

INTRODUCTION

Cardiac rehabilitation has proven beneficial in cardiovascular patients and is strongly recommended for secondary prevention after a coronary event.[1 2] It has been shown to improve quality of life, functional capacity (FC) and re-hospitalisation rates.[3 4] Despite these recommendations, overall utilisation of cardiac rehabilitation is often low.[5–7] The addition of novel methods of rehabilitation may increase overall compliance with cardiac rehabilitation. Recent technological advancements have led to the miniaturisation of technologies that may alter the perception of exercise and may lead to increased motivation and better adherence.[8]

Virtual reality (VR) is a computer-generated simulation of a real or imaginary environment in which the user is able to interact.[9]

The user primarily receives visual feedback via a head mounted device, flat screen or projection, which may be accompanied by other sensory feedback such as audio and touch. The user interacts with the environment via motion capturing devices such as cameras or through more simple devices such as a mouse or joystick.[10] VR can be further subclassified based on the degree of immersion. Fully immersive VR involves a perception that the user is within a three-dimensional world generated by the software while a non-immersive VR system involves the user interacting with a two-dimensional environment via a flat screen.

The use of VR has been adopted in a variety of therapeutic ways such as physical rehabilitation in neurological diseases, rehabilitation for various psychiatric illnesses and postcancer rehabilitation in breast cancer survivors.[10–14]

Our subject of interest is the application of VR technology in the field of cardiac rehabilitation. It has been used during both aerobic exercises and relaxation exercises separately. VR-based aerobic exercises (also known as exer-gaming) involve the use of VR devices to simulate a videogame environment in which the user is given physical tasks that are completed via interaction with the virtual environment. This is proposed as a more interesting and enjoyable experience rather than repetitive exercises.[15 16] It is also easily adjustable in terms of intensity and duration and has been hypothesised to promote greater adherence, motivation and satisfaction with cardiac rehabilitation.[17 18] Blasco-Peris *et al*[19] did not find any significant difference in exercise capacity with exer-gaming in comparison to conventional cardiac rehabilitation. However, there were limitations due to the low number of studies included along with the patient's young age and predominantly male gender.

Psychosocial management is a core component of cardiac rehabilitation that is often overlooked.[20] Components such as stress and anxiety have been shown to lead to increased incidence of coronary artery disease and also contribute to a poorer prognosis in patients with history of coronary artery disease.[21] The implementation of psychosocial programmes in cardiac rehabilitation has been variable based on resources available and the clinical setting in which the rehabilitation programme is conducted. Hybrid and home-based cardiac rehabilitation programmes are a particular area of concern as it is more likely that psychosocial assessment may be neglected in this setting.[22] VR-based relaxation exercises involve the creation of a virtual environment in which the user performs simple tasks, which promote mindfulness and relaxation similar to the mindful meditation.[23 24] Prior studies have shown that VR-based relaxation exercises lead to improved procedural anxiolysis in general.[25] There has also been an improvement in anxiety related to cardiac catheterisation procedures in prior studies.[26–29]

In our meta-analysis, we wish to assess whether the addition of VR (fully immersive or non-immersive) leads to an improvement in anxiety and FC compared with standard cardiac rehabilitation at any phase of rehabilitation. We aim to assess both VR-based exer-gaming as well as VR-based relaxation exercises. This will include recent studies and will also include more types of VR-based interventions than previously studied.[9 19] We will evaluate all cardiac aetiologies for which cardiac rehabilitation is recommended. We will include both home-based and centre-based rehabilitation programmes. We believe that this review will lead to a deeper understanding of the impact of VR technology and will help in our assessment of alternative methods of cardiac rehabilitation.

Review question

To evaluate the effectiveness of VR-assisted cardiac rehabilitation in improving anxiety and FC as compared with standard cardiac rehabilitation (home-based or centre-based) in patients diagnosed with at least one cardiac disease referred for cardiac rehabilitation.

METHODS AND ANALYSIS

This systematic review and meta-analysis will include randomised controlled trials. This protocol is reported according to the published Preferred Reporting for Systematic Review and Meta-analysis—Protocol guidelines.[30]

Search strategy and participants

All the articles searched from the selected databases using a comprehensive search strategy developed by a librarian will be imported into EndNote20. The search strategy includes a mix of keywords and controlled vocabulary terms for the concepts of Cardiac Rehabilitation and Virtual Reality and has been conducted in the following academic research databases: MEDLINE (via Ovid and PubMed), CINAHL (via EBSCO), Cochrane Central Register of Controlled Trials [CENTRAL] and EMBASE (via Embase.com). The searches in MEDLINE, CINAHL and EMBASE also included validated search filters for randomised controlled trials.[31–34] These databases will be searched from inception until the time of final analysis to ensure all the articles which meet out inclusion criteria are included.

Inclusion and exclusion criteria

Inclusion criteria will be based on the Population, Intervention, Comparison and Outcomes (PICO) framework (table 1) and will include adult patients (>18 years of age) diagnosed with at least one cardiac disease and referred for cardiac rehabilitation programme. This programme should include the addition of VR software and gadgetry during the rehabilitation process. We will only include randomised controlled trials published in English language. Exclusion criteria: we will exclude all the non-English randomised control trials; clustered control trials, observational studies, case series and case reports.

Table 1 Eligibility criteria for inclusion

Study selection	This systematic review and meta-analysis includes only RCTs published in English language from inception till the end of study period. Hybrid studies, cross over trial, observational studies and case series were excluded.
Participants	Adult population (18 years or older) diagnosed with at least one cardiac disease and referred for cardiac rehabilitation programme using VR (fully immersive or non-immersive). Cardiac diseases include but are not limited to ischaemic heart disease, non-ischaemic cardiomyopathy, heart failure and valvular heart disease.
Intervention	Patients participate in cardiac rehabilitation with some form of virtual reality devices during training sessions. These devices may be immersive (user interacts within a three-dimensional world generated by software) or non-immersive (user interacts with a two-dimensional environment generated by a software via screen such as a computer screen or a TV screen etc).
Comparator	Patients participate in cardiac rehabilitation training sessions under supervision of a cardiac rehabilitation professional at a hospital or a cardiac rehabilitation centre or at home.
Outcomes	Anxiety assessed using standardised questionnaires like HADS-A and STAI. Physical activity assessed as FC measured in PVO_2.

FC, functional capacity; HADS-A, Hospital Anxiety and Depression Scale; PVO_2, peak oxygen uptake; RCT, randomised controlled trial; STAI, State Trait Anxiety Inventory; VR, virtual reality.

Description of study groups

VR-assisted cardiac rehabilitation: patients participate in cardiac rehabilitation with some form of VR devices during training sessions. These devices may be immersive (user interacts within a three-dimensional world generated by software) or non-immersive (user interacts with a two-dimensional environment generated by a software via screen such as a computer screen or a TV screen, etc.)

Standard cardiac rehabilitation

Patients participate in cardiac rehabilitation training sessions with supervision of a cardiac rehabilitation professional at a hospital or a cardiac rehabilitation centre or at home.

Study selection and data extraction

After removing the duplicates, two reviewers (ZB and AS) will independently review the full text of the articles based on the defined inclusion and exclusion criteria. Any conflicts will be resolved by discussion between the two reviewers. The outcome measures evaluated will be anxiety assessed by standardised questionnaires and the FC measured in peak oxygen uptake (PVO_2).

The data extraction strategy will be similar to our previous study.[35] The data will be extracted from the selected articles on Microsoft Excel Spreadsheet under specific headings for the VR-based cardiac rehabilitation and standard cardiac rehabilitation. These data will include total population of intervention arm, and comparator arm; duration of study period and difference in anxiety scores and FC for the intervention group and the comparator group. (tables 2 and 3) The difference in anxiety and FC will be calculated using simple arithmetic prior to filling in the tables. In addition, higher SD of the outcome measures (anxiety and FC) reported in the studies will be recorded in the spreadsheet to maintain uniformity in collected data.

Outcome measures

The outcome assessment methodology will be similar to our previous study.[35] The outcomes will be assessed by measuring the differences in the anxiety scores and FC between the two time points. The first time point will be the start of the intervention period, and the second time point will be the end of the intervention period for the VR arm and the end of the rehabilitation period for the comparator arm. The end points of the two arms can differ slightly based on the duration of rehabilitation period. The anxiety score will be assessed using validated standardised questionnaires such as the Hospital Anxiety and Depression Scale and the State-Trait Anxiety Inventory.[36 37]

FC measured in PVO_2 will be taken as the standard of measure. Any article that mentions FC measured differently will only be included in the meta-analysis if it could be converted into PVO_2 using standardised formula.

Any non-quantitative data or articles not including the standard measurements and which cannot be converted into the standard measures will not be included in statistical meta-analysis but will be mentioned in the narrative description.

Quality and risk of bias assessment

Cochrane Risk of Bias tool will be used to assess the bias in the included studies. Articles will be evaluated on five components which include: (1) bias arising from the randomisation process, (2) bias due to deviations from intended interventions, (3) bias due to missing outcome data, (4) bias in measurement of the outcome and (5) bias in selection of the reported result. Each of these

Table 2 Data extraction for anxiety

Study author and year	Total population in intervention group	Change in anxiety from baseline	SD	Total population in control group	Change in Anxiety from baseline	SD	Duration of intervention (weeks)
Anxiety assessed using standardised questionnaires.							

Table 3 Data extraction for functional capacity (FC)

Study author and year	Total population in intervention group	Change in FC from baseline	SD	Total population in control group	Change in FC from baseline	SD	Duration of intervention (weeks)
FC measured in peak oxygen uptake (mL/kg/min).							

domains will be assessed as one of the three; low risk of bias, some concerns and high risk of bias. The overall risk of the study will also be reported.

Data synthesis

The results will be assessed on the basis of intention-to-treat analysis. We will use mean and SD for continuous variables. The results will be pooled using standardised mean difference with 95% CI for both anxiety and FC scores. The effect estimates of the pooled studies will be calculated using fixed effect model when heterogeneity is not significant. Otherwise, DerSimonian and Laird random effect model will be used to calculate the effect estimates. Heterogeneity will be assessed quantitatively using Q statistics[38] and I^2 >60% will be considered significant heterogeneity. Publication bias will be assessed using Funnel plot and Egger's test if more than 10 studies are included. A p value of <0.05 will be considered significant. Subgroup analysis and sensitivity analysis will be considered based on the level of heterogeneity of the effect estimates, number of studies included, type of VR gadgetry employed and the type of standardised anxiety questionnaires used. The certainty of body of evidence will be assessed by Grading of Recommendations Assessment, Development and Evaluation (GRADE) method if publication bias is calculated. Data analysis will be conducted using Stata SE version 15.0 (College Station, Texas).

DISCUSSION

Cardiac rehabilitation has shown benefits in improving the mortality, FC and quality of life in cardiac patients.[3 39] Despite strong recommendations and improvement in the referral rates,[40] the overall utilisation of cardiac rehabilitation remains low.[5–7] Several barriers have been identified,[41] and a further decline in participation at the cardiac rehabilitation centres was seen during the COVID-19 pandemic.[42] However, there has been an emphasis on the provision of high-quality healthcare services and improved efficiency and effectiveness closely considering cost and resource utilisation consistent with Health 4.0 goals.[43] VR offers the potential to surmount the limitations of physical factors and provide a patient-centred, customised, easily accessible, motivating and an enjoyable experience with the rehabilitation process. This novel technology includes the interaction of users with a three-dimensional or two-dimensional environment generated by the software. The degree of human–digital interaction is determined by the type of VR, and this can be achieved via computers, mobile devices with graphic cards, or head-mounted displays embedded with position trackers.[44] VR-related therapies have shown improvement in the upper limb motor function in patients with stroke[45] and also anxiety in patients with lung disease[46] during rehabilitation process. We plan to evaluate the effectiveness of VR technology in cardiac rehabilitation for improvement in anxiety and FC compared with standard cardiac rehabilitation.

CONCLUSION

This meta-analysis will provide a comparison between VR-assisted cardiac rehabilitation and standard cardiac rehabilitation in terms of anxiety and FC. It will help us assess the viability of VR-assisted cardiac rehabilitation as an effective alternative to reduce cardiac rehabilitation-related anxiety. With the results of this study, we wish to contribute to the growing body of evidence that VR-assisted technologies are an exciting avenue, which may provide novel benefits to cardiac patients.

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Contributors All authors have contributed to the protocol manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data sharing is not applicable as no datasets generated or analysis conducted.

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