Integrating exercise interventions into routine care for mental illness and cancer : An implementation science approach

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Integrating exercise interventions into routine care for mental illness and cancer: An implementation science approach

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Candidate Declaration

This thesis contains no material that has been extracted in whole or in part from a thesis that I have submitted towards the award of any other degree or diploma in any other tertiary institution. No other person's work has been used without due acknowledgment in the main text of the thesis. All research procedures reported in the thesis received the approval of the relevant Ethics/Safety Committees.

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Publications

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Presentations

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*** Czosnek L**, Richards J, Zopf E, Cormie P, Rosenbaum S, Rankin N. Evaluating implementation outcomes for physical activity interventions integrated in routine cancer care: A systematic review. *International Society of Behavioral Nutrition and Physical Activity.* Auckland, New Zealand. 24–27 June 2020.

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Czosnek L, Cormie P, Zopf E and Rosenbaum S. Translating evidence to practice: A meta-review of physical activity effectiveness research and implications for mental health policy. *Society for Mental Health Research Conference.* Canberra, Australia. 6–8 December 2017.

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List of Abbreviations

BCT: Behaviour Change Technique

BCW: Behaviour Change Wheel

CFIR: Consolidated Framework for Implementation Research

EBIs: Evidence-Based Interventions

EPA: European Psychiatry Association

EPP: Early Psychosis Program

ERIC: Expert Recommendations for Implementing Change

IOF: Implementation Outcomes Framework

IRLM: Implementation Research Logic Model

NCDs: Non-Communicable Diseases

NDIS: National Disability Insurance Scheme

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PSAT: Program Sustainability Assessment Tool

RCTs: Randomised Control Trials

RE-AIM: Reach Effectiveness - Adoption Implementation Maintenance

SMI: Serious Mental Illness

TDF: Theoretical Domains Framework

Glossary of Key Terms

Adoption - the decision of an organisation or community to commit to and initiate an evidence-based intervention (1, p. 23).

Cancer - a large group of diseases that can start in almost any organ or tissue of the body when abnormal cells grow uncontrollably, go beyond their usual boundaries to invade adjoining parts of the body and/or spread to other organs (2).

Contextual factors - Context consists of a constellation of dynamic and complex interacting variables. Contextual factors may include the broader political, social, and organisational characteristics as well as the more immediate, local level-features for the implementation of the intervention (1, p. 33).

Determinants - also commonly referred to as barriers and facilitators, that is, factors that enable or hinder the implementation strategy from eliciting the desired effect (3, p. 2).

Dissemination - an active approach of spreading EBIs to the target audience via determined channels using planned strategies (1, p. 22).

Evidence-based interventions - interventions with proven efficacy and effectiveness. Interventions may include programs, practices, processes, policies, and guidelines (1, p. 20).

Exercise - is a subset of physical activity that is planned, structured and repetitive, performed for the purpose of improving or maintaining physical fitness (4, p. 129).

Framework - a structure, overview, outline, system or plan consisting of various descriptive categories (e.g., concepts, constructs or variables) and the relations between them that are presumed to account for a phenomenon (5, p. 2).

Generalisation - the extent to which the results of a given study are potentially generalisable to a wider or unspecified population, to another setting, or another time (6, p. 2).

Integration - the term integration in the implementation science literature is often used interchangeably with that of ‘penetration’. It is used in this thesis to recognise the breath of implementation science constructs covered (i.e., implementation and sustainability).

Implementation - the process of putting to use or integrating EBIs within a setting (i.e., implementation practice) (1, p. 22).

Implementation outcomes - the effects of deliberate and purposive actions to implement new treatments, practices, and services (7, p. 65).
This thesis primarily focuses on four implementation outcomes:

> *Acceptability* - the perception among implementation stakeholders that a given treatment, service, practice, or innovation is agreeable, palatable, or satisfactory (7, p. 67).
>
> *Fidelity* - the degree to which an intervention is implemented as it was prescribed in the original protocol or as it is intended by the program developers (7, p. 69).
>
> *Penetration* - the integration of a practice within a service setting and its subsystems (7, p. 70). From a service system perspective, the construct is also like *reach* in the RE-AIM framework.
>
> *Sustainability* - Five key constructs are identified that contribute to the sustainability definition: 1) after a defined period of time; 2) the program, clinical intervention, and/or implementation strategies continue to be delivered and/or 3) individual behaviour change (i.e., clinician, patient) is maintained; 4) the program and individual behaviour change may evolve or adapt while 5) continuing to produce benefits for individuals/systems (8, p. 1).
>
> The interventional studies in this thesis (chapters 5, 6, and 7) define and measure sustainability as an outcome that includes: 1) continued intervention components; 2) evolution over time; and 3) a process in place to measure health outcomes. Constructs were measured after at least 12 months of delivery.

Implementation research - seeks to understand the processes and factors that are associated with successful integration of an EBI within a particular setting (i.e., a worksite or school) (1, p. 26).

Implementation science - the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into routine practice (9, p. 1).

Implementation strategy - methods or techniques used to enhance the adoption, implementation, and sustainability of a clinical program or practice (10, p. 1).

Mechanism of change - process or event through which an implementation strategy operates to affect a desired implementation outcome (3, p. 2).

Mental disorder - are syndromes characterised by a clinically significant disturbance in an individual's cognition, emotional regulation, or behaviour that reflects a dysfunction in the psychological, biological, or developmental processes that underlie mental and behavioural functioning. These disturbances are usually associated with distress or impairment in personal, family, social, educational, occupational, or other important areas of functioning (11). This thesis includes a broad range of mental disorders, termed *mental illness*.

Model - a deliberate simplification of a phenomenon or a specific aspect of a phenomenon. Models can be described as theories with a more narrowly defined scope of explanation; a model is descriptive, whereas a theory is explanatory as well as descriptive (5, p. 2).

Non-communicable diseases - also known as chronic diseases, tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioural factors (12). Many can be prevented by reducing lifestyle risk factors such as tobacco use, harmful alcohol use, physical inactivity and eating unhealthy diets.

Physical activity - any bodily movement produced by skeletal muscles that results in energy expenditure (4, p. 129).

Routine practice - are the practices for use in the routine care, of all patients, at all times, in all healthcare settings, and are determined by the circumstances of the patient, the environment and the task to be performed (13).

Scale up - deliberate efforts to increase the impact of health service innovations successfully tested in pilot or experimental projects so as to benefit more people and to foster policy and program development on a lasting basis. Scaling up requires a combination of horizontal (i.e., replication and expansion) and vertical (i.e., institutional, policy, political, legal) scaling up efforts (1, p. 25).

Theory - a set of analytical principles or statements designed to structure our observation, understanding and explanation of the world (5, p. 2).

Transferability - the extent to which the outcomes of a successful health intervention evaluated in a primary context can be achieved in a target context (6, p. 2).

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Abstract

Exercise has been established as an effective intervention that can improve health outcomes in people living with a non-communicable disease (NCD), including mental illness and cancer. Despite the evidence, exercise is not routinely integrated into the treatment of most NCDs. This phenomenon is described as the research-to-practice gap with implementation science seeking to increase the uptake of evidence-based interventions (EBIs), such as exercise, in practice. Multiple factors and processes contribute to the suboptimal use of EBIs in practice. This includes the lack of formative approaches to establish research evidence that is relevant for implementation and scientific methods that explain EBI adoption, implementation, and sustainment. This thesis applies an implementation science approach to explore how exercise EBIs can be integrated into routine healthcare to treat NCDs. This is explored in two NCDs, mental illness and cancer, and through the two following sub-aims:

- Conduct novel evidence synthesis for mental illness and cancer to understand how different synthesis methods can support improved implementation in practice.
- Explore how healthcare organisations have successfully implemented exercise EBIs within the routine practice for treating mental illness and cancer.

To address the first sub-aim, unique approaches were applied to two systematic reviews that were conducted in mental illness and cancer. For the first systematic review, a meta-review design was used to synthesise the evidence on the effectiveness of exercise EBIs for mental illness. Effectiveness was defined in clinically useful terms including the anticipated health benefits, safety and cost of exercise EBIs. Although positive effects on health outcomes (i.e., symptoms of mental illness, quality of life, and physical health outcomes) were reported in the majority of reviews, limited safety information and no cost data were identified.

For the second systematic review, efficacy studies were excluded to investigate the real-world implementation outcomes of exercise EBIs for cancer care. Implementation outcomes were aligned with Proctor and colleagues' Implementation Outcomes Framework (IOF), and the review revealed that the most common implementation outcomes assessed were adoption and feasibility. Penetration and sustainability were infrequently measured, and implementation fidelity was difficult to establish because exercise protocols were poorly reported.

In sum, the unique methods used in the two systematic reviews enabled the synthesis of broad and contextually relevant information valuable for implementation practice. The research gaps identified suggest that there is significant scope to produce more practice-relevant evidence.

To address some of these gaps and the second sub-aim of this thesis, two implementation studies that explored how healthcare organisations have successfully implemented exercise EBI's in mental health and cancer were conducted. For both studies, a case study design and theoretically-informed approach were used to develop an explanation for the implementation process that included the identification of determinants, implementation strategies, and implementation outcomes. Four data sources informed the studies: semi-structured interviews, document review, observations, and administering the Program Sustainability Assessment Tool (PSAT). Framework analysis was applied, and a theory-informed logic model was developed. Linking implementation science frameworks through the logic model elucidated the causal pathways of implementation. Second, the methods facilitated synthesis across sites to support generalisable knowledge.

The first implementation study evaluated an exercise EBI implemented within a youth mental healthcare service. Over 40 determinants that influenced implementation of exercise EBIs and a similar number of implementation strategies were identified. Several activities aided implementation, including the creation of a new clinical team and the auditing and provision of feedback on physical healthcare practices (including exercise). Exercise acceptability was high, and many strengths (identified via the PSAT) contributed to EBI sustainability. However, implementation fidelity was challenging to establish, and penetration was low.

The second implementation study was a multiple case study on the implementation of exercise EBIs across three cancer care settings. Across the sites, 18 determinants and 22 implementation strategies were consistent. Sixteen determinants, 24 implementation strategies, and implementation outcomes differed across the sites. Via the commonalities, 11 common causal pathways were developed, wherein the mechanisms theorised to support implementation include: 1) developing knowledge; 2) building skills and capability; 3) securing resources; 4) generating optimism and 5) simplified decision-making processes associated with exercise; 6) developing relationships (social and professional) and support for the workforce; 7) reinforcing positive outcomes; 8) developing capability to action plan through evaluations and 9) interactive learning; 10) aligning goals between the organisation and the EBI; and, 11) establishing a consumer-responsive service. These mechanisms represent transferable elements of the implementation process that can inform future implementation efforts.

This thesis uses implementation science to increase our understanding of the evidence, factors, strategies and processes required to implement exercise EBIs in practice. Improved implementation knowledge will help shape healthcare so people living with a NCD can access evidence-based care, such as exercise.

1.0 CHAPTER ONE: Introduction

1.1 Preface

Knowledge is of no value unless you put it into practice

Anton Chekhov

Implementation science is enjoying its moment in the spotlight. Despite being a nascent research discipline, it is tackling a vexing issue that has frustrated the research community for decades. *How do we move evidence into practice?* Researchers can spend their whole life toiling away in laboratories, hopeful of making the next ground-breaking discovery. In healthcare, humankind has benefited from the fruits of this labour, with the introduction of vaccines and medical treatments that mean people now enjoy a longer, healthier life (14). However, many researchers also lament lost opportunities and harbour an uneasiness about our future capacity to effect change on a large scale (15, 16).

This unease is rooted in the knowledge that most evidence does not impact practice. Healthcare, defined as the organised provision of medical care to individuals or a community, can be very imprecise, where failures in care are common. To illustrate, approximately 25% of eligible patients in the United States participate in cardiac rehabilitation post-myocardial infarction (17), despite evidence suggesting that this lessens the likelihood that secondary events will occur (18-20). Handwashing is one of the most important, simplest and least expensive interventions to reduce infections and antimicrobial resistance, yet international compliance with hand hygiene practices are poor (21-23). Hypertension is a leading risk factor for cardiovascular disease and all-cause mortality, yet approximately only one in five people have their condition controlled (24, 25). Compounding these failures, systemic social disadvantage results in inequitable in healthcare, meaning that the people who are most in need are least likely to receive care (26).

Although the purpose of implementation science is simple (27) – to implement evidence – this hides the many challenges researchers and practitioners face when attempting to bring evidence into practice. Implementation science is a multi-level, multi-stage and multi-dimensional pursuit, meaning it can be challenging to describe or understand. Unpacking this complexity through implementation science elucidates the range of processes and activities that enable the adoption, implementation, sustainment, and dissemination of effective EBIs (9, 28, 29).

In this thesis, the methods of implementation science are applied to understand how exercise EBIs are implemented in routine healthcare practices for people with a NCD, focusing on two specific NCDs - mental illness and cancer. Exercise is a safe and effective EBI that can improve health outcomes in people with NCDs (30, 31). Pedersen and Saltin summarised the evidence of the efficacy of the use of exercise as a treatment for 26 different chronic conditions, including psychiatric disorders and some cancers (31). Despite the evidence, in 2020, 35.5% of adult cancer survivors in the United States reported undertaking no physical activity (32). International studies similarly reflect insufficient levels of physical activity in people with cancer (33-35). In people with serious mental illness, estimates suggest that around 50% do not meet physical activity guidelines (36). Worldwide, decreasing the number of people who are not meeting physical activity guidelines by 10% could avert around half a million premature deaths each year (37). As such, increasing population-wide levels of physical activity should be a global health priority. To support this priority, there is an opportunity to leverage implementation science and improve the integration of exercise EBIs in routine healthcare practices.

1.1.1 Overview of thesis chapters

This thesis does not seek to specialise but investigate several implementation science constructs. This includes novel evidence synthesis methods, determinants of implementation, implementation strategies (including mechanisms of change), implementation outcomes (including a focus on the later stages of implementation) and innovative theoretical applications. In isolation, each construct could be the basis for a thesis. However, they are also related concepts that complement and build on each other.

This thesis is separated into four sections and includes eight chapters (plus appendix). Five chapters have been published in peer review journals, and one is currently under review. The language used in each chapter is associated with the journal for each peer-reviewed publication. As such, some terms are used interchangeably across chapters, including physical activity and exercise. Notwithstanding this, it is recognised that the description of EBIs throughout this thesis is more accurately defined as exercise - a subset of physical activity (4).

Section 1 (chapters 1 and 2) contains an introduction to this thesis and an overview of implementation science. Referencing the existing literature, it explores how the methods of implementation science can be applied to improve the uptake and use of exercise EBIs in healthcare.

To expand, Chapter 1 begins with an exploration of the research-to-practice gap, which catalysed implementation science as a dedicated research field. The fundamental constructs of implementation science applied through this thesis are introduced, and then a detailed rationale is provided for focusing on exercise, mental illness and cancer. Australia is the setting for the implementation research studies described in Section 3. As such, the governance of the Australian healthcare system is summarised. The chapter concludes by highlighting the contribution that this thesis makes to the related literature.

Chapter 2 contains an introduction to one of the most commonly-used frameworks in implementation science (38) - the Consolidated Framework for Implementation Research (CFIR) (39). The CFIR is applied to explore exercise EBIs delivered in healthcare and the determinants that influence implementation in this setting. The early introduction of the CFIR is required because understanding the contextual nuance of the implementation setting, such as revealed through a determinant analysis, is a critical and formative step within the implementation process (40).

Section 2 (chapters 3 and 4) includes two systematic reviews that adopt novel evidence synthesis methods. Implementation science recommends using innovative evidence synthesis approaches that may be better suited to implementation than traditional methods (1). This offers a relevant, real-world perspective on the literature through inclusive, context-sensitive approaches.

Chapter 3 explores the evidence for exercise as a treatment for mental illness. It does this via a meta-review or umbrella review, which is a systematic review of systematic reviews. The aim of the meta-review was threefold; 1) to summarise the effectiveness of exercise EBIs as a treatment for mental illness; 2) to synthesise past systematic reviews and meta-analyses to improve practical application that can inform healthcare decision-making; and 3) to provide recommendations for priority research to support evidence-translation efforts. Unique to this study was an implementation-focused definition of effectiveness. The definition included three elements: 1) clinical outcomes (i.e., *what* *are the expected health benefits of exercise EBIs for people with mental illness?)*; 2) a service level outcome (i.e., *are exercise EBIs safe in this population group?)*; and 3) an implementation outcome (i.e., *what is the likely cost of the exercise EBI?).* The findings of this study provide important practice-based evidence and elucidate whether researchers are exploring the questions decision-makers need answered when considering the implementation of an EBI.

Chapter 4 continues to explore novel evidence synthesis methods, this time focusing on cancer and exercise. The study's origins are based on the differing characteristics of efficacy, effectiveness and implementation research (which are expanded upon in Section 2.1.3 of this chapter). Chapter 4 is a systematic review that aimed to examine the implementation outcomes evaluated under real-world conditions when exercise is implemented for the treatment of cancer. Real-world conditions were sought by excluding efficacy studies and summarising the evidence from effectiveness and implementation trials. The study introduces the second implementation science framework applied in this thesis – Proctor and colleagues' IOF (7). The findings of this study illustrate the status of implementation outcomes in exercise and cancer. It provides future directions on pragmatic, real-world research needed for translational impact.

Section 3 includes three chapters on how healthcare organisations have implemented exercise EBIs and whether they were successful. The section consists of an overview of the methodology (Chapter 5) and case studies that evaluated the implementation process in mental illness (Chapter 6) and cancer care (Chapter 7).

Chapter 5 contains a detailed account of the case study methodology. It includes the method used in chapters 6 and 7 and a description of how different implementation science frameworks can be drawn together systematically to explain the implementation process. It introduces a taxonomy of implementation strategies, the ERIC (10) and a program logic, the IRLM (41), which were applied in this thesis. The approaches described in this chapter introduce several innovative concepts in implementation science. This includes: 1) identifying how causal pathways can be developed via the IRLM; 2) demonstrating the utility and flexibility of the case study methodology to address implementation science priorities; and 3) identifying how findings of case studies can be synthesised across different contexts and settings when guided by relevant theoretical application. The study findings provide a roadmap for future implementation researchers who wish to combine multiple constructs and frameworks to explain the implementation process.

Chapter 6 contains the results of a mental illness case study. Covid-19 mandates impacted the original study protocol because onsite observations could not be conducted, and visits to additional sites could not be completed. Notwithstanding these challenges, the specific aims of the study were to: 1) understand the context, strategies and outcomes that contribute to exercise EBIs implementation within an early psychosis program (EPP); and 2) explore how the learnings from a case study can help define successful implementation. To the best of our knowledge, this is one of the first studies in exercise and mental illness that systematically uses implementation science principles to identify context, strategies and outcomes. This is important because it provides the foundations for future implementation research in NCDs.

Chapter 7 contains the results of a multiple case study on cancer, the focus of which was to develop generalisable (or transferable) knowledge by replicating the methods described in Chapter 5 across multiple sites. The specific aims were to: 1) identify the commonalities and differences in determinants, implementation strategies and implementation outcomes across different exercise and cancer services; and 2) develop an explanatory causal pathway for the implementation process from the common elements identified across services. The study findings include identified areas of commonality across sites that may be important for future implementation efforts.

The final section, Chapter 8, discusses the overall body of work included in this thesis and areas for future research. It discusses the findings in the context of the research gaps the thesis sought to address and identifies the strengths and limitations of the work. Finally, it summarises the critical developments of this work and its contributions to the understanding of how exercise EBI are implemented in the treatment of NCDs, specifically focusing on mental illness and cancer.

Figure 1 provides an overview of the thesis structure.

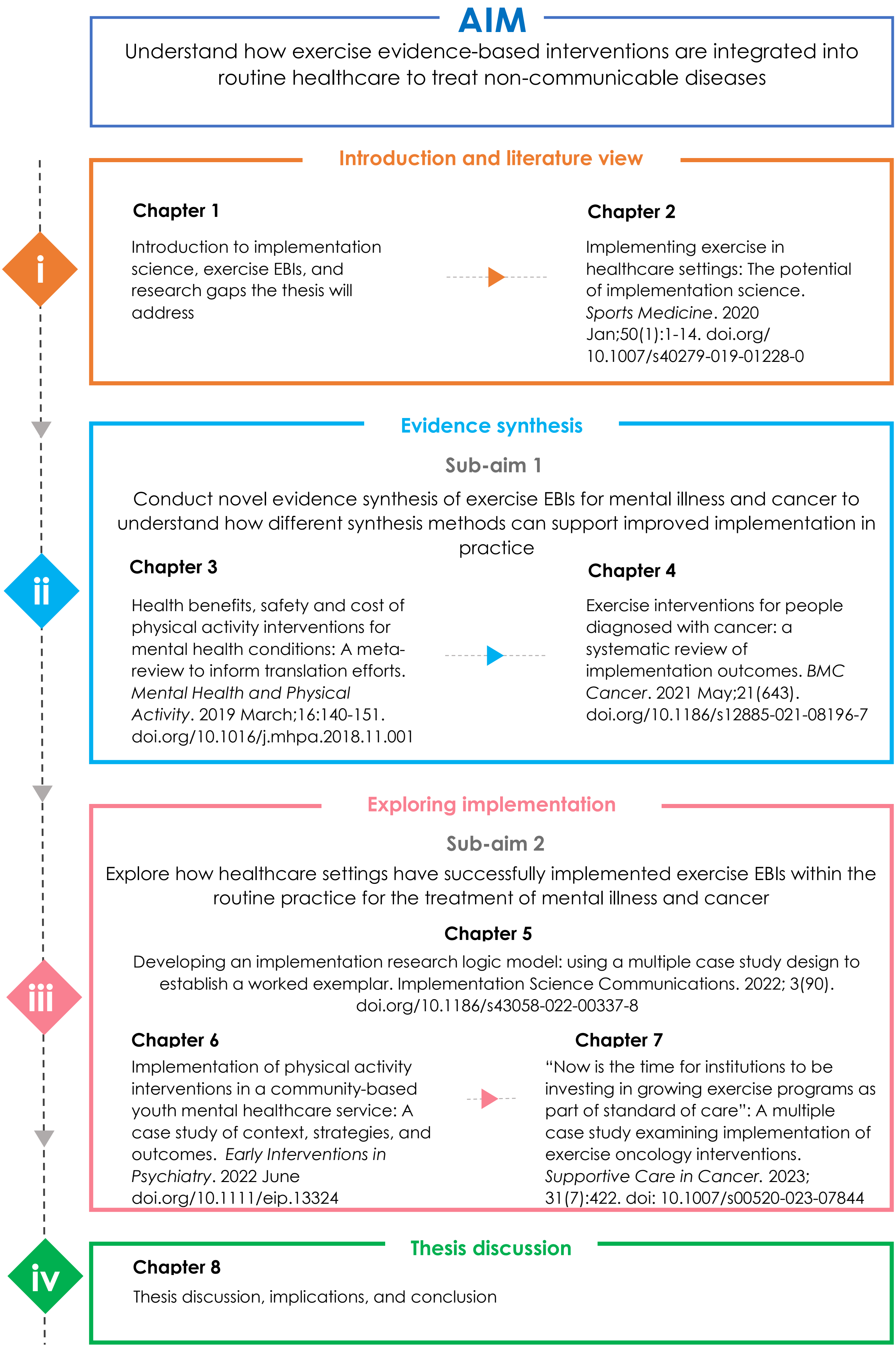


Figure 1: Thesis structure, sections and chapters

1.2 Introduction to implementation science

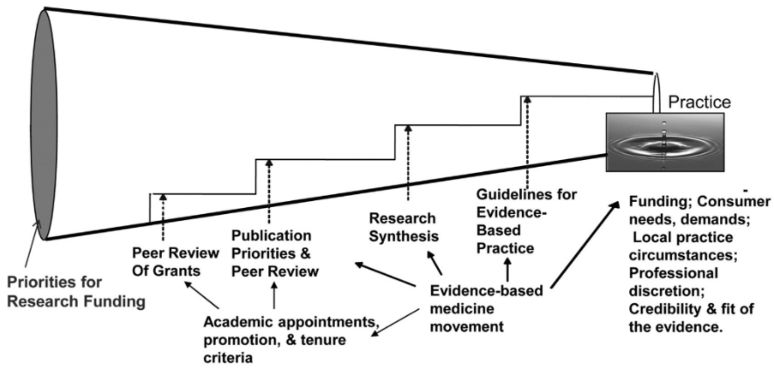
The uptake and use of EBIs in routine healthcare practice are notoriously slow and complex pursuits. A widely cited statistic suggests that it takes around 17 years for as little as 14% of evidence to inform practice (42, 43). Among the EBIs that make this transition, approximately 60% are delivered in line with evidence-based guidelines (44, 45). There are many implications of failed implementation: the money spent on research that finds new and better ways of treating a disease or improving health outcomes is wasted (46). Healthcare organisations may fail to optimise efficient and effective service delivery within resource-constrained environments (47). Opportunities to enhance population-wide health outcomes are lost (48). The struggle to integrate EBIs into routine practice is broadly described as the research-to-practice gap (49, 50). Implementation science has evolved as a dedicated research discipline to address this issue (9).

1.2.1 The research-to-practice gap

Two interrelated factors contribute to the research-to-practice gap: 1) the time-lapse between scientific discovery and its use in practice; and 2) the small percentage of research findings used in routine practice (49). Seventeen years and 14% is the best estimate of the research-to-practice gap (42, 51). It is a composite measure based on the time and attrition of original research as it moves through development, translation and use in practice (52). Historically, this process was conceptualised as several, sequential and somewhat linear stages (45, 53, 54). It commenced with basic biomedical findings, progressing through efficacy and effectiveness studies to synthesis in systematic reviews that informed clinical practice guidelines. Green conceptualised this process as a *leaking* pipeline (Figure 2) (49). They illuminated the multiple points where knowledge was lost and the many years it takes for this process to play out, resulting in the research-to-practice gap. Research waste commences with research priorities that inform grant funding, incentivising scientists to mould proposals to fit pre-established criteria. Limited funding and high rates of unsuccessful grant applications mean many worthy interventions are never funded or progress to implementation. There are also more efforts directed at discovering the next, shiny and new innovation than improving the implementation of existing practices (45, 55, 56). Much time and evidence are lost through the peer review and publication process (57-59). This includes publication biases, where null findings often go unreported (55, 60). Research is then synthesised via systematic reviews, which typically filter out copious studies that do not meet pre-defined inclusion and quality criteria (61). The remaining evidence informs clinical practice guidelines, wherein minimal resources are directed towards the active uptake of evidence and changing existing healthcare practices.

Figure 2: The leaking pipeline depicting the multiple points where knowledge is lost as it progresses for practice.

Re-produced from: Lawrence W Green, Making research relevant: if it is an evidence-based practice, where's the practice-based evidence?, *Family Practice*, Volume 25, Issue suppl_1, December 2008, Pages i20–i24. doi: 10.1093/fampra/cmn055, by permission of Oxford University Press



Many of the issues illuminated above are currently the subject of corrective actions, including reframing research priorities to reduce waste (62), requirements to demonstrate the potential *impact* of research through grant applications, re-defining what constitutes and how we produce meaningful evidence and the recognition that null findings contribute import knowledge to scientific inquiry (63). Taken together, for implementation science to address the research-to-practice gap, efficiencies must be gained across the spectrum of activities that comprise research production and use in practice.

1.2.2 Implementation science and how it applies to the research-to-practice gap

Implementation science is an applied, multi-disciplinary research field. Its recognition as a specialist area of scientific inquiry emerged over the last two decades (64), with origins in Roger's 1960s diffusion of innovation theory (65) evidence-based medicine (66) and psychological theories of behaviour (67).

The multi-disciplinary nature of implementation science is possibly best illustrated by a seminal framework developed in the field of healthcare - Greenhalgh and colleagues' diffusion of innovations in service organisations (68). Greenhalgh and colleagues systematically summarised 13 discrete fields of study to conceptualise how to spread and sustain innovations in health service delivery and organisations. To illustrate the transposition, health promotion concepts such as *reach* and *uptake* are reflected as outcomes of positive lifestyle choices. The evidence-based medicine movement can be seen as the spread of the best available external clinical evidence from systematic research (integrated with individual clinical expertise) on managing diseases and symptoms. Knowledge utilisation studies can demonstrate how individuals and teams acquire, construct, use and share knowledge.

As an applied science, implementation science ideally comprises a team of practitioners, researchers and health administrators working together on the practice of implementation (69-71). Implementation science considers both *research* and *practice* in its dual aims (72) to: 1) develop generalisable knowledge that contributes to scientific knowledge accumulation (9, 29); and 2) produce knowledge that improves practice. Recognising its purpose and the intertwining of implementation science and implementation practice, researchers often need to balance rigour with pragmatism, that is, rigour in faithfully applying the scientific constructs that underpin implementation science with what is feasible, practical and realistic to achieve in practice.

In the following section, I explore the critical constructs of implementation science and the pragmatic considerations applied to address the research-to-practice gap.

1.2.3 Types of research

Green and colleagues described why there is a problem using evidence by referencing the earlier, linear research translation pipeline. This approach considered translation a rationale process whereby research was automatically and simply transferred from researchers to users. The research translation pipeline is now considered an iterative and overlapping process that requires concerted action to enable the use of evidence in practice (73-75). Common to the pipeline is the positioning of different types of research and study designs that dominate the stages of research. Over time the stages within the translational research process have evolved (45, 76). Currently, these are best described as T0-T4 (77).

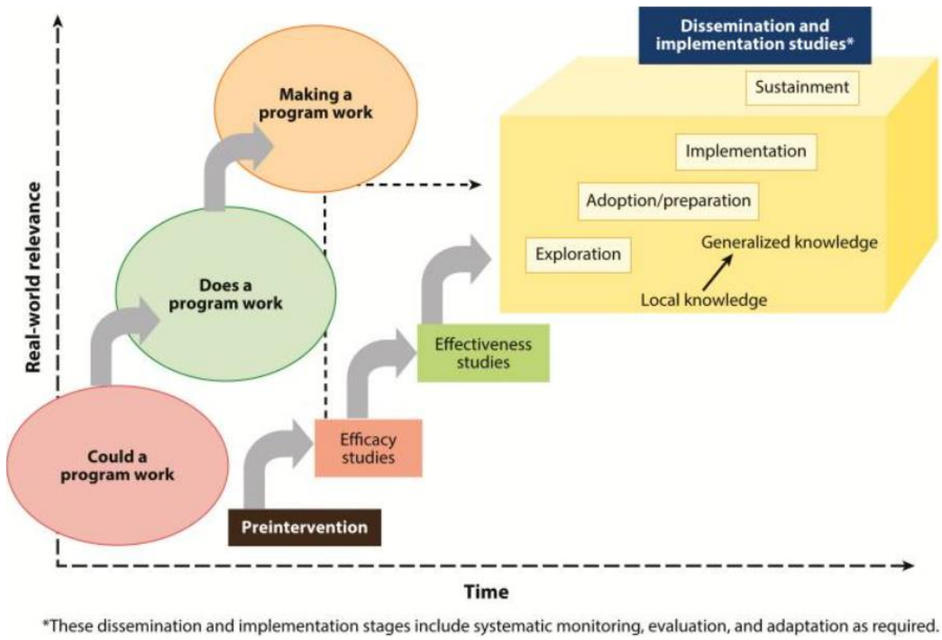
- **T0** - basic biomedical research that does not include human trials;
- **T1** - early-stage clinical trials that commence testing in humans;

- **T2** - establish the effectiveness of interventions in humans and develop clinical practice guidelines;
- **T3** - focus on the translation uptake of effective interventions in clinical practice;
- **T4** - scaling up effective interventions, including evaluations and outcomes in broader populations.

The overlap in research stages indicates that each phase should continue to build on previous stages (74, 78). Ideally, intervention efficacy and effectiveness are established before implementation, and widespread uptake in populations occurs. Albeit, this is not always the case, with some EBIs moving directly from piloting to widespread implementation (56). This has possibly resulted in implementation failures and redacted support for EBIs (79). Figure 3 illustrates the research translation phases and focus of enquiry in different study types. To exemplify, efficacy and effectiveness studies seek to understand whether an intervention works while dissemination and implementation research focuses on making the intervention work in the real world (78, 80).

Figure 3: The research translation stages and focus of studies

Reproduced from: Deenik J, Czosnek L, Teasdale SB, Stubbs B, Firth J, Schuch FB, et al. From impact factors to real impact: Translating evidence on lifestyle interventions into routine mental health care. Translational Behavioral Medicine. 2020;10(4):1070-3. doi: 10.1093/tbm/ibz067 (*Adapted from Brown et al. 2017 (78)*)



A focus on patient or clinical outcomes is common in efficacy and effectiveness studies (29). Efficacy studies demonstrate whether an intervention works under ideal conditions. Effectiveness studies determine whether efficacious interventions continue to work in real-world environments (81). In contrast, implementation research focuses on organisational or system-level outcomes and seeks to understand *how* to implement effective interventions. Table 1 summarises efficacy, effectiveness and implementation research characteristics.

Table 1: Differences in characteristics of efficacy, effectiveness, and implementation research (28, 80, 81)

	Efficacy studies	**Effectiveness studies**	**Implementation research**
Research Question	Does this intervention work under ideal conditions?	Does this intervention still work in a real-world setting?	How can we make the intervention work?
Validity Priority	Internal > External	External ≥ Internal	External
Population and Sample	Highly selective for the condition of interest Few comorbidities Willing and motivated participants Several exclusion criteria applied to the study Sample size is generally smaller	Selected for the condition of interest but reflective of the general population Comorbidities resemble those in the general population to which the results will be applied Less stringent inclusion/exclusion criteria, with only those who are ethically or practically unable to participate being excluded A larger sample size that is reflective of the real-world users of the intervention	Varies but typically focused on those who use or attend the healthcare setting Often includes delivery staff as opposed to service users OR No population – study focuses on the characteristics of site/setting for implementation The sample size matches the research question and rationale provided
Setting	Highly resourced and optimal or ideal setting is provided	Real-world and/or replication of normal clinical settings with typical resourcing	Real-world settings Context for implementation is illuminated

Intervention	Intervention is delivered by highly trained and qualified staff or research team members. Intervention is delivered in compliance with the research protocol, and typically with no concurrent interventions being delivered.	Staff selection and training are representative of regular providers and training. Greater flexibility with intervention delivery may apply and occur concurrently with other interventions typically seen in standard healthcare settings	Regular providers and training are involved in delivery. Studies focus on implementation strategies that may/may not be led by research team members.
Outcome Measures and Data Collection	Many primary and secondary outcomes may be collected with the intent of capturing all possible outcomes associated with the intervention Adverse events recorded	Outcomes are more targeted or representative of what could feasibly be collected in real-world settings.	Outcomes typically focus on organisational or system-level measures Fidelity/adaption recorded
Analysis	Intensive data analysis may be possible	Accounts for missing data or wide heterogeneity in the analysis	Various methods are employed

Implementation research adopts different study designs better suited to implementation and the greater requirement for external validity (78, 82, 83). For example, adopting different evidence synthesis methods to improve the relevance and real-world application, or hybrid designs to concurrently evaluate effectiveness and implementation [32, 24]. Mixed method studies are also common. They can elucidate stakeholder experiences and uncover the complexity of implementation alongside evaluations of the implementation process (82, 84). Unlike study designs that seek to remove or control for extraneous variables to ensure internal validity, implementation research embraces these factors. Healthcare, and other settings where implementation research occurs (i.e., schools, workplaces), are often dynamic and ever-changing. As such, ongoing efforts are often required to evaluate, refine and adapt practices and processes to optimise implementation and ensure the continued use (or sustainability) of EBIs over time (85).

1.2.4 Theoretical approaches

To encourage progress and the development of generalisable knowledge and facilitate shared understanding, implementation scientists advocate using relevant models, theories, and frameworks (hereafter *frameworks*) (5, 38, 86). Appropriate theoretical application can help guide the research process, deepen analyse and understandings of the implementation process and elucidate causal relationships between a phenomenon and outcome (87). This can support the identification of the conditions needed for successful implementation, predict how implementation may unfold and test hypothesised causal relationships between variables. In recent years, many new or revised frameworks have been developed, making it difficult for researchers to determine the best selection and how to apply the frameworks in studies (38, 88). Even when researchers use a framework, it can be poorly executed or incomplete in its application (89, 90). In contemporary implementation studies, Per Nilsen's work arguably guides much of the delineation and categorisation of frameworks (5). Nilsen defined five different types of frameworks with three different aims that can be applied in implementation research (5). The three broad aims of using implementation science frameworks are: "1) describing and/or guiding the process of translating research into practice (process models); 2) understanding and/or explaining what influences implementation outcomes (e.g. determinant framework, classic theories, implementation theories); and 3) evaluating implementation (evaluation framework)" (5, p. 3). The differing aims of frameworks mean it is often necessary to apply multiple frameworks in implementation research.

Acknowledging the vast number of implementation frameworks, and the need to apply more than one in studies, citation analysis may help researchers select, conceptualise, and operationalise more commonly used frameworks in studies (91, 92). The more common use of some frameworks has also led to systematic reviews of their specific application in studies, further supporting researchers to understand how common frameworks are applied in implementation studies and where opportunities exist to build on prior research (89, 93-95). Table 2 summarises the most common implementation frameworks identified in recent citation analysis.

Table 2: Most commonly used implementation theories, models, and frameworks (referred to as frameworks) according to citation analysis (91, 92)

Rank (according to Skolarus et al. citation analysis 2016)	**Framework**	**Rank (according to Sullivan et. al citation analysis 2021)**	**Framework**
1	Knowledge to Action Framework	1	Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) 1.0
2	A Conceptual Model for the Diffusion of Innovations in Service Organizations	2	**Consolidated Framework for Implementation Research**
3	Sticky Knowledge	3	Greenhalgh Diffusion of Innovation
4	Theoretical Domains Framework	4	Community-Based Participatory Research
5	Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM)	5	Quality Enhancement Research Initiative
6	**Consolidated Framework for Implementation Research**	6	Promoting Action on Research Implementation in Health Services
7	Conceptual Model of Evidence-Based Practice Implementation in Public Service Sectors	7	Pragmatic-Explanatory Continuum Indicator Summary 2
8	**Implementation Outcomes Framework**	8	Behavior Change Wheel
9	Implementation Effectiveness Model	9	**Implementation Outcomes Framework**
10	Promoting Action on Research Implementation in Health Services	10	Replicating Effective Programs
Rank 1 = Most commonly cited framework **Bold** = frameworks in this thesis			

Across this thesis, the CFIR is the determinant framework that was applied (described in detail in Chapter 2) and the Implementation Outcomes Framework is the evaluation framework that was applied (described in detail in Chapter 4). This thesis did not use a process model; instead, the ERIC and IRLM were applied, which allowed the CFIR and OF (plus the process) to be combined within one study. The method for integrating all frameworks plus taxonomies (ERIC) and process (IRLM) is described in Chapter 5.

1.2.5 Determinants

The determinants that influence implementation are often presented as barriers and enablers within determinant frameworks in a structured list of discrete constructs that aid or inhibit implementation (39, 68, 88, 96, 97). These constructs are often summarised across multiple levels and grouped as classes or domains (39, 68, 98). The grouping of constructs across levels and acknowledgment of multi-level influences (i.e., level of EBI, individual (patient or healthcare provider), organisation, and environment) implies a systems-based approach to implementation. Aligned with systems thinking, relationships exist across levels and within determinants. However, these relationships are not always specified in determinant frameworks. Determinants can also be the factors that are implied when researchers discuss the context of implementation (99, 100). Notwithstanding that context is sometimes poorly described and understood in implementation research, understanding context is important because EBIs rarely work in the same way when implemented in different settings (99-101). Determinants may also be the independent variable manipulated in studies to determine the effects on implementation outcomes (86).

1.2.6 Implementation strategies

Implementation strategies are central to implementation science. They are the actions we take to help people and places use an EBI (27). Existing taxonomies document implementation strategies, including the ERIC (which was applied in this thesis), the Effective Practice and Organisation of Care (EPOC) and the Behaviour Change Wheel (10, 102, 103). The ERIC taxonomy identifies 73 implementation strategies that are commonly used to support implementation (10). Implementation strategies can be single, discrete strategies (i.e., a computer-generated reminder) or multi-component strategies that combine different strategies to effect change (i.e., education sessions, printed resources, and incentivising desired behaviour) (104, 105).

Given that the determinants that influence implementation exist across multiple levels, implementation strategies are ideally designed to address multi-level barriers. However, a mismatch often exists between determinants and implementation strategies, and it can be difficult to select appropriate strategies (106, 107). Specific strategies may be used because they always have been used, or organisations do not select and tailor the strategies to the multi-level determinants. For example, strategies are developed that target healthcare providers' behaviours but fail to address organisational barriers. An emerging focus for implementation strategy research is exploring the mechanisms of change (108, 109). Most implementation research does not identify mechanisms of change (110). However, they are the constructs of behavioural or organisational change that seek to explain why implementation strategies work. For example, mechanisms may include increasing motivation, technical knowledge and material resources or augmenting group identity to elicit change. By identifying mechanisms of change, implementation scientists are beginning to understand the active ingredients of different implementation strategies.

Despite mechanisms of change being underreported in implementation studies, several methods exist to support their identification. Implementation mapping is a 6-step process that encourages researchers to systematically plan the development and selection of implementation strategies which includes explicating how (mechanism of change) the implementation strategy is proposed to work (111). The implementation research logic model supports the identification of mechanisms of change via developing the relationship between an intervention, its implementation, and the outcomes of those efforts (41). Further, two large-scale research projects are working to better link specific implementation strategies and their change mechanisms (112, 113). The Behaviour Change project has undertaken a comprehensive process (evidence synthesis, consensus development, and concordance between these two processes) to develop an online tool that links the Behaviour Change Wheel with specific mechanisms (114). Lewis and colleagues are developing causal pathways for 30 common implementation strategies to confer the strength of the relationship between common strategies and mechanisms (113). This project will extend to developing reliable, valid and pragmatic measures of mechanisms, which will be disseminated through a dedicated mechanisms knowledge hub website. The development of online tools supports communal knowledge within implementation science to improve the identification, selection, and implementation of various strategies designed to bring about change.

1.2.7 Implementation outcomes

If determinants are the independent variable in a study, then implementation outcomes are the dependent variable. By measuring implementation outcomes, we can begin to understand whether implementation was successful (115) and what implementation strategies were used during the implementation process that led to this success. Implementation success is delineated from intervention success in implementation research to avoid conflating outcomes (80, 116). For example, concluding that an intervention is ineffective in practice when implementation failures contributed to sub-optimal intervention outcomes. Implementation outcomes are often documented within evaluation frameworks (5). Commonly-used evaluation frameworks are Reach Effectiveness, Adoption, Implementation, Maintenance (RE-AIM), Predisposing, Reinforcing and Enabling Constructs in Educational Diagnosis and Evaluation-Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development (PRECEDE-PROCEED), and Proctor et al. IOF (7, 117, 118). The IOF details eight outcomes: acceptability, adoption, appropriateness, costs, feasibility, fidelity, penetration and sustainability (7), which are described as precursors to service and client-level outcomes. If an EBI is not implemented well, then we will fail to see the desired change in service or clinical outcomes (for example, a *safe* service that is promptly provided and improves a patient's *symptoms*) (7). The complete list of service level outcomes identified by Proctor et al. includes *efficiency, safety, effectiveness, equity, patient-centred* and *timeliness*. The clinical outcomes are *satisfaction, symptomology* and *function*. Different implementation outcomes are suggested to have greater relevance in varying stages of implementation (7). For example, acceptability and adoption are better evaluated in the earlier stages of implementation while penetration and sustainability are likely to be helpful in the later stages.

1.3 Exercise, mental illness and cancer

1.3.1 Exercise evidence-based interventions

The focus of implementation efforts is EBIs. Exercise is the EBI of interest in this thesis. As noted earlier, exercise is a subset of physical activity with the difference between physical activity and exercise surmised as one of intent. Exercise is a deliberate act to improve health or physical performance (119), whereas physical activity includes any bodily movement. Piggins recently proposed a new definition of physical activity that is better aligned with system-based thinking (120).

It recognises the array of factors, such as interests, emotions and relationships, that comprise to understand what physical activity means to different people.

Evidence demonstrating the efficacy of exercise at improving health outcomes has been accumulating since the 1950s (121). Seminal works during this time focused on exercises protective effects against the development of coronary heart disease. The Morris group found that physically active London bus conductors had a lower risk of cardiac events than their sedentary bus driver colleagues (122). They reproduced their findings in other workforces, including comparing active postmen to sedentary telephonists (123). Since then, epidemiological studies have been conducted on diverse population groups across different parts of the world and extended to other NCDs, including secondary and tertiary prevention (i.e., chronic disease management programs for people with established diseases) (121). Exercise, diet, and education remain cornerstones of Type 2 diabetes mellitus treatment (124-126). Exercise can improve glycaemic control, endothelial function, blood pressure and lipid profile and reduce insulin resistance. Studies have shown that as part of a holistic lifestyle program, exercise can slow the progress of insulin resistance (127). Musculoskeletal conditions, such as back pain, are a leading cause of disease burden worldwide and cost to healthcare systems (128, 129). Exercise is recommended as a first-line treatment for back pain, and a recent Cochrane review demonstrated that exercise improved outcomes for people with chronic lower back pain with moderate consistency (130). People who exercise after myocardial infarction have reduced mortality and lower incidence of further cardiac events (18-20).

The maturity of evidence differs in mental illness and cancer, with the inclusion of exercise in clinical practice guidelines occurring approximately 10 years earlier in cancer compared to mental illness (131-134). Despite this, exercise offers many positive social, physical, and economic outcomes for people and communities experiencing mental illness or cancer, as detailed in the following section.

1.3.2 Mental illness and cancer

The disease burden attributable to NCDs is significant, with 3 in 4 deaths (or approximately 42 million deaths) from chronic conditions occurring each year. Independently, mental illness and cancer significantly contribute to the overall disease burden, resulting in substantial costs to individuals, healthcare systems and societies (135-140). The 2019 Global Burden of Disease study identifies cancer as the second leading cause of NCD burden, contributing 9.93% to the total global disease burden. Mental illnesses are the fifth leading cause of disease burden, at 4.29% (141). Notably, limitations exist concerning how mental illnesses were classified, and when the rate is re-calculated using revised categories of mental disorders, we get an estimated global burden of 13% (142). This places mental illness and cancer in the second and third places, respectively, behind cardiovascular disease at 15.4%.

Australian disease burden studies reflect similarly high levels of burden attributed to mental illness and cancer. In 2018, 18% of the disease burden was attributed to cancer while 13% was attributed to mental and substance use disorders (129). The composition of disease burden differs across conditions, with high rates of non-fatal burden evident in mental illness and higher rates of fatal burden evident in the cancer disease group. Australia's mental healthcare system reforms are projected to produce significant benefits, estimated at over $18 billion annually, due to improved patient quality of life and participation in employment (143). Five-year survival rates for people diagnosed with cancer have steadily improved since the 1990s. However, one in four people are still likely to die from cancer during their lifetime (144).

In mental illness treatment the use of exercise to address disease burden can be aligned with an emerging field of psychiatry termed *lifestyle psychiatry* (145). Lifestyle psychiatry has evolved partly in response to the health inequities that people with mental illness experience. These inequities result in poor health outcomes and a reduced life expectancy, which have been described as a *human rights scandal* (146). Social determinants, which are the conditions in which people are born, work and live, contribute to inequity (147). However, people with mental illness also experience inequitable access to care, reduced quality of care, and higher rates of physical *ill* health compared to people without a mental illness (148, 149). This includes higher rates of metabolic illness, cardiovascular disease and respiratory illnesses than the general population (150). Exercise, together with other lifestyle factors, can positively influence both physical and mental health outcomes. For this reason, clinical practice guidelines (from the European Psychiatry Association) recommend exercise: 1) as a treatment for mild to moderate depression; 2) as an adjunct treatment for schizophrenia-spectrum disorders; and 3) be prescribed to improve the physical health of people with serious mental illness (132). Most evidence has accumulated in depression, where guidelines recommend people participate in 2-3 exercise sessions per week (of 45-60 minutes duration) comprising aerobic and/or aerobic and resistance training (132). Chapter 3 provides further information about exercise effectiveness (including various modalities) for different mental illnesses.

For people diagnosed with some cancers (i.e., breast, colon, prostate), there is strong evidence that exercise can ameliorate many common side effects of cancer treatment (151-154). An international multidisciplinary roundtable summarised the evidence and outlined the beneficial effects of exercise on anxiety, depressive symptoms, fatigue, physical function and quality of life for survivors of cancers (152). Further, exercise may reduce the relative risk of mortality and reoccurrence for some cancers (155). Clinical practice guidelines recommend that people with cancer should progress towards achieving at least 150 minutes of moderate-intensity (or 75 minutes of vigorous-intensity) aerobic exercise and 2-3 resistance exercise sessions per week (151).

In response to the disease burden and recognition that exercise may play a vital role in improving health outcomes, as evidenced through its inclusion in clinical practice guidelines, there is a growing focus on the need to embed exercise in standard care for both conditions (156-159). Alongside these calls, workforce projections suggest that cancer and mental illness will be growth areas for exercise professionals in the coming years (160, 161).

1.3.3 Australian healthcare system

Healthcare governance and structures, political influence and cultural expectations of the healthcare system vary considerably across countries (162-164). The ability to generalise findings from this thesis must be contextualised within the boundaries of the healthcare system of the host site. The interventional studies described in this thesis were conducted on populations in Victoria and New South Wales, Australia.

The governance of Australian healthcare is complex (165). There are three tiers of government (i.e., federal, state and local), and each plays a role in funding and/or regulating and managing healthcare. The healthcare system has its foundations in universal access through the Medicare system and voluntary private health insurance (164, 165).

Medicare provides for care in primary (i.e., general practice), secondary (i.e., specialist services) and tertiary (i.e., public hospitals) settings. Medicare is funded at the federal level. However, the public hospital system is managed at the state level, and most general practices operate through private business models. By contrast, the private hospital system is legislated at the state level (i.e., Victorian Health Service Act 1988, NSW Private Health Facilities Act 2007).

Medicare also provides some coverage for dental care and allied health services in hospitals and community settings, such as psychology and physiotherapy services (166). Sometimes dental and allied health services are owned and operated as private businesses, while in other cases, they are managed by a tier of government. The introduction of private business models means these organisations must also comply with corporate laws, in addition to obligations set forth through Medicare. Further, the regulation of healthcare professionals occurs through an independent authority. Depending on the profession, this can be via the Australian Health Practitioners Regulation Agency, Medical Board of Australia, or independent allied health and other practitioners board (i.e., Exercise and Sports Science Australia) (167, 168).

Alongside the universal Medicare system, Australia has a voluntary private healthcare system, in which people can select an insurance policy to cover their healthcare needs. As of 31 March 2022, 45.1% of the Australian population had private health insurance for hospital treatment, and 55% had private insurance for general treatment (169). Individuals with private healthcare can choose to receive services in a public hospital as a private patient. The Australian Government has invested in several policy initiatives designed to keep the uptake of private health insurance high and disperse the load away from the Medicare system, including the following:

- Private health insurance rebate - a government-provided refund to reduce the premiums individuals pay for private healthcare (170). Its purpose is to make private health insurance affordable for individuals.
- Lifetime Health Cover - adds a *financial loading* to private health insurance premiums for every year a person is over 30 years old and does not have insurance. Its purpose is to encourage people to purchase private health insurance earlier in life and maintain insurance for life (171).
- Medicare Levy Surcharge - a tax paid by individuals who earn over $90,000AUD and do not have private health insurance. Its purpose is to encourage people who can afford private health insurance to purchase a policy (172).

Depending on the private health insurance policy purchased, individuals can be covered for both in-hospital care and community-based services (i.e., allied health services and dental work), commonly called *extras*. Private health insurance legislation does not allow insurers to fund general practitioner services (173), although they can fund the administration and operating costs associated with running a general practice. Outside of Medicare and private health insurance, some population groups, including veterans, people with a disability and older Australians, may have access to health services through other means (i.e., National Disability Insurance Scheme (NDIS), the Veteran Entitlements Act 1986 & Regulations and the Aged Care Act 1997 & Regulations).

In Australia, exercise EBIs are funded through the Medicare system, selected private health insurance policies and schemes such as NDIS. In private practice, Medicare subsidises five visits to an exercise physiologist or physiotherapist for people with chronic conditions (174), albeit additional services may be available if accessed through community health services. The level of subsidy and what is subsidised through private health insurance varies and is typically covered through *extras* (175). Access to exercise EBI within tertiary settings is also highly variable. For example, Dennett and colleagues (176) attempted to describe exercise oncology services across Australia. They found that a mix of services were delivered across the states through different funding streams and varying access depending on the service locations (176). To our knowledge, a similar pursuit has not been attempted for exercise EBIs and mental healthcare. The complexity of healthcare in Australia means some people will have ready access to exercise EBIs, while others may have to pay out-of-pocket costs. This can impact the uptake of exercise EBIs.

1.4 Contributions of this thesis to the related literature

The research-to-practice gap is explored at several points within this thesis. It considers both the status of evidence through the application of novel evidence synthesis methods and implementation by conducting implementation research projects.

The first contribution this thesis makes to the literature is exploring the evidence-base in mental illness and cancer through non-traditional evidence synthesis methods. The hierarchy of evidence states that systematic reviews and meta-analyses from randomised control trials are the best available evidence with which to inform clinical practice guidelines and, thus, support decision-making (177, 178). Many scholars have challenged the established ranking of study designs put forward through the hierarchy (179-181), and different methods have evolved to improve the application of evidence in practice (182). This includes determining the strength of a study design based on the research question and context of the study (74). For systematic reviews designed to support implementation, this means conducting realist reviews, meta-reviews (also described as overviews of reviews or umbrella reviews), rapid reviews or mixed study reviews that include study designs other than randomised control trials (183-186).

Many systematic reviews and meta-analyses document the efficacy of exercise EBI in mental illness and cancer treatment (187-192). However, to our knowledge, few seek to use novel synthesis methods that may better suit implementation efforts than traditional methods. This is a significant gap to address for several reasons. First, traditional systematic reviews narrow, focused questions are challenging to apply to broad, complex issues (193, 194). Meta-reviews are growing in popularity because they may be an efficient method to support guideline and resource development and decision-making as part of the translational research pipeline. Implementation scientists are applying meta-reviews to support evidence synthesis activities. However, the method is sparsely applied to exercise studies (195). Further, it is yet to be applied to exercise EBIs for mental illness treatment that includes a research question targeting translational efforts.

Second, because traditional systematic reviews typically contain summaries of RCTs, authors often summarise intervention effects under ideal conditions and not in real-world environments. EBIs typically experience a reduction in effect size or impact when translated for use in real-world environments (196). This phenomenon, referred to as the *voltage drop*, describes the gradual reduction in the effect of an EBI as it moves through the research pipeline. Although some authors contend that the voltage drop is no longer seen as an inevitable by-product of implementation (197), it exposes the limitations of continuing to synthesise efficacy studies to demonstrate the positive effects of exercise EBIs.

The second gap this thesis addresses is specifying the implementation strategies used to support the successful implementation of exercise EBIs, by applying a relevant taxonomy. Existing studies on exercise EBIs for cancer and mental illness have identified implementation strategies, such as reminder systems and decision prompts, printed education materials and training, as potentially effective strategies (198-202). However, strategies are not routinely identified and described with reference to an existing taxonomy. Sometimes, these strategies are identified through descriptive works, not via empirical research (203). Further, research from other fields suggests that organisations can sometimes employ over 30 implementation strategies (204-206). Comprehensive reporting is needed to elucidate the full breadth of activities undertaken to implement exercise EBIs in mental illness and cancer and help organisations select the most relevant or appropriate strategies to use.

The third gap this thesis seeks to fill is to contribute to the literature that explores the later stages of implementation (i.e., penetration and sustainability). Research on sustaining EBIs receives less attention than initial works on the adoption and implementation of new practices (207-209). Many challenges have been identified with studying sustainability, driven by conceptual ambiguity in terminology and approach (210, 211). Implementation scientists have also defined sustainment and sustainability differently, with these concepts proposed to either predict (sustainability) or be an actual implementation outcome (sustainment) (211, 212). Further, sustainability is listed both as a stage within the implementation process and the outcome of implementation efforts (209, 213). There are also fewer validated tools, compared to the earlier stages of implementation, that can be applied to measure sustainment (214). Despite the apparent need to sustain effective EBIs, the lack of research (possibly reflective of the nascent stage of implementation science as a scientific discipline) has made knowledge accumulation and progress challenging (215).

The final gap this thesis seeks to address is to apply and combine relevant implementation science frameworks to explain the implementation process. This includes identifying mechanisms of change associated with implementation strategies within the causal pathway. While Nilsen defined different types of frameworks used in implementation science, there are nuances within these categories that contribute to sub-optimal theoretical application in implementation studies. For example, different types of process models exist to explain the process of designing an EBI for implementation at a given site, versus process models that support implementation, spreading and scaling (40, 216, 217). Likewise, different determinant frameworks exist that describe the factors that influence implementation outcomes for interventions, clinical practice guidelines and evidence uptake (39, 218, 219). Researchers have also identified that frameworks of the same defined purpose, such as the CFIR and Theoretical Domain Framework (TDF), can also be used harmoniously in the same study (220). Finally, although evaluation frameworks are considered a discrete category, many measurement tools have been established to evaluate implementation based on constructs within determinant frameworks

(214). Some evaluation frameworks are also applied formatively to plan for implementation. This thesis seeks to address this gap by applying relevant implementation science frameworks to explain the implementation process within a broader scope of work.

1.5 Thesis aims

This thesis aims to understand how exercise EBIs are integrated into routine healthcare for the treatment of NCDs. This aim is explored in the context of two specific NCDs, mental illness and cancer. Two sub-aims inform the response to the primary research aim.

1. Conduct novel evidence synthesis of exercise EBIs for mental illness and cancer to understand how different synthesis methods can support improved implementation in practice.
2. Explore how healthcare organisations have successfully implemented exercise EBIs within the routine practice for treating mental illness and cancer.

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2.0 CHAPTER TWO: Implementing exercise in healthcare settings: The potential of implementation science

2.1 Preamble

Chapter 1 introduced exercise EBIs, implementation science and the planned contribution the body of work contained in this thesis will make. In this chapter, a literature review is conducted that explores the determinants that influence the implementation process when exercise EBIs are integrated into the treatment for NCDs. To do so, a common conceptual framework in implementation science, the CFIR, is introduced and we demonstrate its application to exercise EBIs. The review concludes by highlighting identified research priorities of implementation science. By highlighting the research priorities, we aim to facilitate contribution to these priorities by exercise EBI researcher's interested in implementation.

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2.2 Published manuscript

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Implementing exercise in healthcare settings: The potential of implementation science

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Abstract

Exercise is an efficacious therapy for many chronic diseases. Integrating efficacious evidence-based interventions (EBIs), such as exercise, into daily healthcare practice is a slow and complex pursuit. Implementation science seeks to understand and address this phenomenon by conducting studies about the methods used to promote the routine uptake of EBIs. This article aims to explore implementation science and a common conceptual framework in the discipline, the Consolidated Framework for Implementation Research (CFIR), as it applies to exercise EBIs. We conclude by offering recommendations for future research that leverage implementation science priorities to highlight the potential of this research field for advancing the implementation of exercise EBIs.

Key Points

- There is a large evidence base supporting the role of exercise in effectively contributing to the management of many chronic diseases.
- The Consolidated Framework for Implementation Research (CFIR) is a comprehensive implementation framework that provides an overarching view of implementation and the determinants that can influence the implementation of exercise in healthcare settings.
- This article provides recommendations for future research that draw from implementation science priorities to improve the implementation of exercise in routine healthcare.

1. Introduction

Translating research findings into daily healthcare practice is a slow and, in many cases, complex and challenging pursuit. It takes an average of 17 years to turn a small percentage of research into practice that benefits patient outcomes [1]. Studies from the United States [2] and many other countries, including Australia [3], suggest that patients receive evidence-based care less than 60% of the time. While numerous studies document the development and scientific testing of evidence-based interventions (EBIs) (defined as interventions with proven efficacy and effectiveness designed to improve healthcare outcomes [4]), most of these are not successfully implemented into practice [5]. Therefore, research efforts are often wasted [6], and communities may fail to derive the purported benefits of these EBIs. This common phenomenon is described as the research-to-practice gap [7].

Addressing the research-to-practice gap has garnered attention across many research fields [8-10], including public health [11], where understanding the implementation of physical activity interventions in practice is the focus of many studies [12-15]. Exercise is a subset of physical activity [16], and in this article, we explore the research-to-practice gap in exercise EBIs. We focus on exercise EBIs prescribed by practitioners within an individualised approach [17] to treat established chronic diseases.

2. Reasons for the research-to-practice gap

There are many reasons for the research-to-practice gap [18-20]. Healthcare workers may lack knowledge about the EBI, fail to see a need to introduce the EBI, or find the EBI is not feasible to integrate within their existing routines [19, 21]. This is notwithstanding the practical aspects of implementation that demand organisations allocate sufficient expertise, funding and time to support the uptake and continued use of the EBI [19, 21]. A lack of studies that focus on, and funding for, translational and implementation research has further impeded progress. That is, far more efficacy studies are funded and conducted [6] compared to implementation-focused research [4].

In exercise EBIs factors that contribute to the research-to-practice gap include; research studies that use exercise protocols that are impractical to replicate in real-world healthcare settings [22], lack of data about the optimal 'dose' of the exercise EBI required to produce clinically meaningful outcomes [23], a lack of knowledge about the benefits of exercise EBIs [24] and technical expertise to prescribe exercise EBIs [25] within the multi-disciplinary healthcare team, the travel distance between the exercise EBI in proximity to a patient's home [26] and limited resourcing (i.e., funding that subsidises patient participation costs and carving-out dedicated time within clinical encounters to facilitate uptake of exercise EBI) [27, 28]. Further, there is a suggestion that non-pharmacological interventions, including exercise, are poorly described in research studies and lack adequate marketing and regulation compared to pharmacology interventions [29].

3. Introducing implementation science

Implementation is "the process of putting to use or integrating evidence-based interventions within a setting" [4, p22] to address the research-to-practice gap. Implementation science is "the scientific study of *methods* to promote the systematic uptake of research findings and other evidence-based practices into routine practice" [30, p1]. The outputs from implementation science are designed to be relevant in real-world healthcare practice. As such, implementation science uses a wide range of study designs [31, 32] that better engage stakeholders and create generalisable knowledge [4]. The designs selected are informed by the research question and typically focus on the health service (team or organisation) or health system level rather than the individual patient [33]. Mixed method designs that collect quantitative and qualitative data are also encouraged because they enable a richer description of the possible determinants known to influence implementation [34, 35].

Identifying the determinants, or barriers and enablers known to influence EBI implementation [36], is an early step in the implementation process [21]. That is, once an assessment of the determinants is conducted, implementation strategies which are the "methods or techniques used to enhance the adoption, implementation, and sustainability of a clinical program or practice" [37, p1], can be planned, designed and enacted to mitigate barriers and activate enablers to support successful implementation [21]. The determinants that influence implementation typically exist across multiple levels - at the level of the EBI, the individual, the organisation and the system level [19, 18, 20]. These determinants have been documented within multiple implementation theories, models and frameworks [38]; as such, researchers are encouraged to select and apply an appropriate theoretical approach within their studies [36, 39].

Models, frameworks, and theories are summarised in a taxonomy by Nilsen [36] and include process models, determinant frameworks and evaluation frameworks, and classic and implementation theories. These frameworks serve three different purposes in studies [36, 40]. First, process models describe the steps involved in translating research into practice. Second, are frameworks that provide details about contextual factors that influence implementation success. This includes determinant frameworks, such as the Consolidated Framework for Implementation Research (CFIR) [18] (see Section 4) and the Theoretical Domains Framework (TDF) [41], a common framework applied in exercise EBI studies. Many implementation science studies use more than one framework to address different aspects of implementation, hence the combined use of the TDF and CFIR in implementation studies [42], despite being of similar theoretical purpose. Third, evaluation frameworks that evaluate the outcomes of implementation. The Reach Effectiveness Adoption Implementation and Maintenance (RE-AIM) [42] framework is a popular evaluation framework used in exercise EBI studies.

4. The Consolidated Framework for Implementation Research (CFIR)

The CFIR is one of the most common determinant frameworks in implementation science [39]. It is described as a meta-theoretical framework that provides an overarching view of implementation [18]. The CFIR was developed through the compilation of 19 previously published theories, models, and frameworks in implementation science [18]. The CFIR identifies 39 separate determinant constructs categorised within five domains, representing the multi-level influences on implementation. The five domains are: 1) *Characteristics of the intervention* that describe the attributes of the EBI that influence implementation; 2) *Characteristics of the inner setting* that describe the factors that influence implementation and are attributable to the host site (i.e., the organisation) where implementation is planned; 3) *Characteristics of the outer setting* is a broad construct that refers to the factors outside the immediate organisation that can influence implementation within the organisation; 4) *Characteristics of the individual* describe the attributes of the individuals involved with implementation (i.e., healthcare providers, patients) that influence implementation outcomes; and 5) the *Process of implementation* illuminates the typical steps involved in moving an EBI into routine practice (See: https://cfirguide.org/constructs/). The CFIR provides a standardised list of determinants that influence implementation outcomes and success [43]. Applying the CFIR (and thus its standardised architecture) to implementation research can also facilitate the cumulation of generalisable knowledge across studies and support replication of EBIs at different sites [43].

The CFIR has been used for many different purposes in implementation science [43]. Damschroder and colleagues [44] applied the CFIR to help explain the variations in the successful implementation of a weight-management program at five different sites [44]. Similarly, the CFIR has also been used to identify important determinants for successful implementation in telemedicine [45] and telephone-based lifestyle coaching [46]. To the best of our knowledge, the CFIR has not been applied extensively within the exercise EBI literature. Given that it provides an overarching view of implementation, greater attention to the CFIR as a valuable framework for better understanding the implementation of exercise EBIs, is warranted. In the following sections we discuss and provide examples for how the determinants that influence implementation can be applied to exercise EBIs. We adopted an exploratory approach and conducted a global search to illustrate the breadth of factors that influence implementation by providing examples for every determinant construct of the CFIR. Recognising that identifying determinants is an early step in the implementation process, we conclude by providing recommendations that draw from identified priorities in implementation science that could augment exercise EBI studies to improve translation and real-world implementation.

<u>*4.1 CFIR Domain - Characteristics of the intervention*</u>

The determinant constructs listed within this domain include [18]: 1) the relative advantage; 2) the level of complexity; 3) adaptability; 4) trialability; 5) intervention source; 6) evidence strength and quality; 7) design and packaging of the intervention; and 8) cost. To illustrate, the *relative advantage* of implementing exercise as part of routine care for people with mental illness is justified because exercise EBIs may contribute to reducing the life expectancy gap (approx. 15 years) in people with serious mental illness. The life expectancy gap is a critical issue within the sector. As such, positioning exercise EBIs as a possible solution to this issue may enhance stakeholder perceptions about the value of implementing exercise EBIs. Table 1 provides examples of how other determinants within the *Characteristics of the Intervention* may apply to exercise EBIs.

Table 1: The CFIR domain of *Characteristics of the intervention*: Determinant constructs and descriptive examples from the exercise literature

Determinant constructs and definitions from the CFIR companion website [47]	**Descriptive examples from the exercise literature**
Relative advantage Stakeholders' perception of the advantage of implementing the intervention versus an alternative solution*.	• In diabetes care, nurses suggested that patients perceive little benefit in engaging in exercise EBIs because they are on medication that has a similar effect. This suggests that the *relative advantage* of adopting an exercise EBI is not evident [48] to stakeholders. • McIntosh and colleagues [49] reported that patients had other conditions that "took priority" (p. e1760) over participation in cardiac rehabilitation. This suggests that the *relative advantage* of participation was not sufficient to support a shift in behaviour. • This barrier may be connected to the *evidence strength and quality* (for example, developing and disseminating the Exercise is Medicine® message). That is, how the exercise EBI is framed may not resonate with all stakeholders, impacting the *relative advantage* of changing practice [50].
The level of complexity Perceived difficulty of implementation, reflected by duration, scope, radicalness, disruptiveness, centrality, and intricacy and number of steps required to implement*.	• Implementing an exercise EBI may require multiple steps completed by numerous people, including initial screening, completing referral forms and initiating a referral to an appropriate service, follow-up with the patient to confirm attendance, arranging transportation if required and coordinating the exercise EBI within the broader suite of treatments that a person may be receiving. To optimise implementation, the EBI should be simplified where possible. • The inclusion of a care coordinator to manage the referral process and patient flow through programs is an implementation strategy that has been employed and can address *the level of complexity* [51].
Adaptability The degree to which an intervention can be adapted, tailored, refined, or	• During implementation, tension exists between maintaining the fidelity of an EBI and adapting the EBI to improve the fit with the host implementation site [52].

reinvented to meet local needs*.	• Beidas and colleagues [51] reported three adaptions were made to a breast cancer exercise EBI to address barriers that arose during the implementation process. This included: 1) working with the staff to individualise the exercise program; 2) hiring a new staff member to optimise the referral process; and 3) adding a follow-up phone call after the initial referral to increase participation in the program. • In exercise EBIs for mental illness [53], the reported adaptions included: 1) changing the pacing of the EBI and duration of the sessions; 2) expanding the sessions to add individualised appointments; 3) adding support from peer support workers or mental health counsellors; and 4) including pharmacy education to advise on psychotropic-induced weight gain. • The components of an exercise EBI that produce individual behaviour change and are suggested to be maintained (and *not adapted)* throughout implementation (for cancer care) include: 1) setting clear goals; 2) the ability to transfer the program from a supervised setting to an unsupervised setting; and 3) support to help patients self-manage.
Trialability The ability to test the intervention on a small scale in the organization, and to be able to reverse course (undo implementation) if warranted*.	• In Australia, university students such as exercise physiologists or physiotherapists have been used to trial new exercise EBIs within mental health settings [54]. This allowed individuals and organisations to work with the new practice before making a bigger commitment, such as hiring staff or changing operating policies and procedures to accommodate the new way of delivering services.
Intervention source Perception of key stakeholders about whether the intervention is externally or internally developed*.	• Matthews and colleagues [55] have proposed an adapted framework for experienced-based co-design (i.e., a participatory method that creates shared ownership and power with the people that will use the product or service) in exercise EBIs and mental healthcare to improve adherence to exercise EBIs. Facilitated co-design of an exercise EBI may improve the perception of *internally developed intervention source*.
Evidence strength and quality Stakeholders' perceptions of the quality and validity of evidence supporting the belief that the intervention will have desired outcomes*.	• Avery and colleagues [56] reported that General Practitioners (GPs) viewed prescribing medication as a more appealing and effective option than prescribing exercise EBIs for patients with diabetes. This suggests that GPs may not value the exercise EBI evidence as highly as pharmacological evidence.

	• Granger and colleagues [57] suggested that a lack of evidence in lung cancer and exercise EBI resulted in poor buy-in from medical staff and a lack of dedicated resources and funding for their services. • How the evidence is tailored for dissemination may influence implementation (i.e., Segar and colleagues [58] suggested that the Exercise is Medicine® message, an initiative designed to encourage more health practitioners to prescribe exercise, is a health-focused message that is useful for clinicians but may not translate favourably for patients).
Design and packaging of the intervention Perceived excellence in how the intervention is bundled, presented, and assembled*.	• EX-MED Cancer has been developed through extensive research and is an exercise program for people with cancer [59]. Investment has been made in designing the entire process. For example, the program is packaged with a consistent visual style (i.e., fonts, colouring, language used in information materials), a central hub has been established to coordinate referrals, and uniformed training is provided to all healthcare professionals delivering the program to ensure consistency in evidence-based delivery [60].
Cost Costs of the intervention and costs associated with implementing the intervention, including investment, supply, and opportunity costs*.	• Dennett and colleagues [27] reported a range of issues associated with a lack of funding that impacted the delivery of exercise EBIs in cancer rehabilitation. This included a lack of funding for exercise equipment, marketing the program, patient access to therapists and navigating the patient's private health insurance policies. • Stoutenberg et al. [61] provided a detailed breakdown of the costs that should be considered as part of implementing exercise EBIs (i.e., costs associated with staffing, training, and technology requirements). Further, they suggested that tracking costs, which may be offset by implementing exercise EBI (i.e., changes in healthcare utilisation, and medication expenditure), would be helpful to demonstrate effectiveness that had practical application.

CFIR = Consolidated Framework for Implementation Research, EBI = Evidence-based Intervention, SMI = Serious Mental Illness (typically defined as schizophrenia, bipolar disorder and major depressive disorder), * = definitions as supplied by the CFIR companion website https://cfirguide.org/constructs/

4.2 CFIR Domain - Characteristics of the inner setting

The determinant constructs within this domain include [18]: 1) structural characteristics; 2) networks and communication; 3) culture; 4) implementation climate (that includes tension for change, compatibility, relative priority, organisational incentives and rewards, goals and feedback and learning climate); 5) readiness for implementation (that includes leadership engagement, available resources, access to knowledge and skills). For example, workplace *cultures* that are not inclusive of exercise are a reported barrier to referral rates and education provided to patients in cancer care [57]. Emerging evidence suggests that alignment is needed between organisational culture and individual constructs (such as *knowledge and beliefs*) to enable implementation [62]. As such, if an organisational culture is not inclusive of exercise, training staff to improve referrals or their technical competencies to prescribe exercise EBI may be ineffective. Table 2 provides examples of how the *Characteristics of the inner setting* may apply to exercise EBIs.

Table 2: The CFIR domain of *Characteristics of the inner setting*: Determinants and descriptive examples from the exercise literature

Determinant Constructs and definitions from the CFIR companion website [47]	**Descriptive examples from the exercise literature**
Structural characteristics The social architecture, age, maturity, and size of an organization*.	• Although many structural factors are fixed, organisations that view other organisations as similar in size, structure, operations, and values are more likely to provide a realistic example that can be modelled [63].
Networks and communications The nature and quality of webs of social networks and the nature and quality of formal and informal communications within an organization*.	• The referral process between oncology providers and physical therapists was a noted barrier in Beidas and colleagues [51] study in cancer care. • Lederman and colleagues [54] report that all multi-disciplinary team members, including nurses, allied health and medical staff, need to be involved in promoting exercise EBIs. • Stoutenberg et al. [61] reported that a primary step in developing exercise EBIs is a network that consists of

	"programs, places and professionals" (p. 3) to support referrals. • In cardiac rehabilitation, pre-approved referrals have been identified as an effective strategy to address referral barriers [64].
Culture Norms, values, and basic assumptions of a given organization*.	• Lederman and colleagues [54] identified "culture and empowerment" (p. 4) as an enabling factor that supported staff to integrate exercise EBIs into mental healthcare services. • Further, Fibbins and colleagues [65] suggested that staff-focused exercise programs present a possible mechanism to address workplace cultures that impede patient access to exercise EBIs.
Implementation climate The absorptive capacity for change, shared receptivity of involved individuals to an intervention, and the extent to which use of that intervention will be rewarded, supported, and expected within their organization*.	• Chor and colleagues [66] suggested that organisations with poor organisational climate are less likely to see value in adopting EBIs. Poor climate presents as staff who are emotionally exhausted, have poorly defined roles and operate in depersonalised environments [66]. Conversely, organisations that are viewed as having a good climate may present by having leaders who lead by example and demonstrate the expected behaviours [67].
Readiness for implementation Tangible and immediate indicators of organizational commitment to its decision to implement an intervention*.	• Furness and colleagues [68] quoted management as taking the opportunity of a "new and expanded" (p. 122) mental health facility to add resources to an existing service that better addressed the physical health issues of patients by hiring an exercise physiologist. Through this process, management also prepared existing clinical staff for the new exercise EBI by providing online resources that detailed how the exercise physiology role may operate in the existing service. • Miller and colleagues [69] described many barriers to implementing exercise EBIs in people with heart failure, including: 1) insufficient funding or staff to support the program; 2) competition - a similar service being offered nearby; and 3) a lack of clinical resources. • Granger et al. [57] reported that a lack of exercise EBI services and time were the main barriers to implementation in cancer care. This included a lack of dedicated referral pathways that could support patients to traverse the health system.

	• Young et al. [70] noted that staff perceptions about: 1) impact on workload; 2) available time; and 3) whether implementing exercise EBIs was part of their job role as barriers to implementation of an intradialytic exercise program. • Demark-Wahnefried and colleagues [71] identified that competing demands in clinical encounters made it challenging for healthcare staff to adequately discuss exercise. A similar finding was observed by Dalzell and colleagues [28] (in cancer care), where competing time pressures of staff resulted in referral delays to the exercise EBI.
CFIR = Consolidated Framework for Implementation Research, EBI = Evidence-based Intervention, * = definitions as supplied by the CFIR companion website https://cfirguide.org/constructs/	

4.3 CFIR Domain – Characteristics of the outer setting

The determinant constructs listed within this domain include [18]: 1) cosmopolitanism; 2) external policies and incentives; 3) patient needs and resourcing; and 4) peer pressure. In the UK, the National Institute for Health and Care Excellence (NICE) provides quality standards that can be included in healthcare audits to support the provision of high-quality, evidence-based care. The quality standards for Type 2 diabetes include the provision of structured education programs (that include physical activity) at diagnosis [72]. *External policies and incentives* can be leveraged through the implementation process to guide implementation of exercise EBI and audit compliance with evidence-based care standards. Table 3 provides examples of how the *Characteristics of the outer setting* may apply to exercise EBI.

Table 3: The CFIR domain of *Characteristics of the outer setting*: Determinant constructs and descriptive examples from the exercise literature

Determinant constructs and definitions from the CFIR companion website [47]	**Descriptive examples from the exercise literature**
Cosmopolitanism	• The relationship between the hospital and the community-based organisation was reported as vital to moving people

The degree to which an organization is networked with other external organizations*.	towards self-managed exercise programs in cancer care [25]. • Lederman and colleagues [54] reported that collaborations were required in mental healthcare to support strong referral pathways. A similar observation was reported by Leach and colleagues [73] in cancer care. • The lack of structured pathways between services (in cancer care) was noted as a referral barrier by Demark-Wahnefried and colleagues [74].
External policies and incentives A broad construct that includes external strategies to spread interventions, including policy and regulations (governmental or other central entity), external mandates, recommendations and guidelines, pay-for-performance, collaboratives, and public or benchmark reporting*.	• In Australia, the state of New South Wales has a policy on physical health care within mental health services that mandate certain activities be undertaken by the mental health service [75]. The Mental Health Commission in that state has also developed an evidence guide for the physical and mental health of people with mental illness [76]. Further, Australia is one of the few countries that subsidises access to healthcare providers skilled in exercise prescription through the tax-payer-funded Medicare system. One could argue that these external policy directives, resources, and funding opportunities create an environment conducive to establishing and integrating exercise EBIs in mental health care. • In the UK, the National Institute for Health and Care Excellence (NICE) guidelines [77] provide minimum-level standards for the care of people with serious mental illness. The recommendation that physical health risk factors should be "audited as part of (a) team report" (p. 170) and to support compliance with the guidelines, included in "board-level" (p. 170) performance indicators, creates a regulatory environment that is conducive to introducing new EBIs, such as exercise.
Patient need and resourcing The extent to which patient needs, as well as barriers and facilitators to meet those needs, are accurately known and prioritized by the organization*.	• Furness and colleagues [68] highlighted that an organisational change and *patient need* were the driving force behind introducing a new exercise EBI in mental healthcare. Sources quoted through the study suggested that a health-promoting environment was lacking for patients, and existing staff did not have the required skills to provide this service. The addition of a new staff member offered patients an opportunity to access exercise EBIs, as opposed to spending their time in the hospital "lay(ing) around" (p. 123). • Murgitroyd and colleagues [78] described designing an exercise EBI to ensure *patient need* was addressed. This included classes available at various locations and times,

	providing written information at the point of referral and follow-up phone calls to engage patients. • *Patient need* has been described in cardiac rehabilitation. It included having classes at different times, group classes that encourage social support, telemetry equipment to monitor patients, and hybrid classes that included home and clinic-based activities to accommodate travel distance [49]. • The experience-based co-design method in Table 1 (*Intervention source*) presents a possible strategy to develop programs that address *patient need*.
Peer pressure Mimetic or competitive pressure to implement an intervention; typically because most or other key peer or competing organizations have already implemented or are in a bid for a competitive edge*.	• The competitive environment or demand for a service/product may also catalyse organisational change [18]. Most entities do not want to lag behind or fail to offer the most effective treatment for a given illness or condition.
CFIR = Consolidated Framework for Implementation Research, EBI = evidence-base intervention, UK = United Kingdom, * = definitions as supplied by the CFIR companion website https://cfirguide.org/constructs/	

4.4 CFIR Domain - Characteristics of the individuals

The determinant constructs listed within this domain include [18]: 1) individual knowledge and beliefs about the intervention; 2) self-efficacy of the individual; 3) individual stages of change; 4) individual identification with the organisation; and 5) other personal attributes. *Individual identification with the organisation* is a broad construct that describes how an individual perceives the organisation, its alignment with their personal values and commitment to the organisation. For example, in some organisations, doctors and nurses may perceive the provision of an exercise EBI as within their normal scope of practice, whereas individuals in other organisations may not. While many organisations have developed resources and tools to support the provision of EBIs [79], if the individual perceives that the task allocation has not occurred in a fair and just manner, they may continue to resist change. Table 4 provides examples of how the *Characteristics of the individuals* may apply to exercise EBI.

Table 4: The CFIR domain of *Characteristics of the individual*: Determinant constructs and descriptive examples from the exercise literature

Determinant constructs and definitions from the CFIR companion website [47]	Descriptive examples from the exercise literature
Individual knowledge and beliefs about the intervention Individuals' attitudes toward and value placed on the intervention as well as familiarity with facts, truths, and principles related to the intervention*.	• Santa Mina et al. [25] suggested that the poor uptake of exercise EBIs in cancer care includes provider-level barriers such as; a lack of exercise prescription skills in clinicians and a perception that exercise may cause injury and increase fatigue and other symptoms in cancer patients. A similar challenge, that is, reduced knowledge about the positive benefits of exercise EBI in cancer, was noted by Dennett and colleagues [27], Demark-Wahnefried et al. [71, 74] and a more recent study by Santa Mina et al. [80]. • Demark-Wahnefried et al. [71] suggested that oncologists have a critical role in engaging people in lifestyle interventions because a cancer diagnosis presents a "teachable moment" (p. 179) whereby patients may be more receptive to behaviour change. This contrasts with evidence from cardiac rehabilitation that suggests the proximity to diagnosis may be an inappropriate time to discuss exercise EBIs – "a lot of people in white coats arrived and told me things. And I had no paper to take notes" [81, p. 5] • Granger et al. [57] suggested that engaging the multi-disciplinary team early in the implementation process (in lung cancer) would facilitate improved knowledge and practice change. Likewise, Dalzell et al. [28] reported that program success (in cancer care) relied on the multidisciplinary teams awareness and advocacy for the exercise EBI. • Avery and colleagues [56] reported similar findings in diabetes (i.e., GPs lacked knowledge about the type, duration and frequency of exercise EBIs) and subsequently developed a tailored training program to address this gap. • The 'Physical Activity and Exercise Toolkit' [82] is a resource developed and implemented across Canada to

	address provider knowledge and beliefs to support the provision of exercise EBIs in diabetes care.
Self-efficacy of the individual Individual belief in their own capabilities to execute courses of action to achieve implementation goals*.	• Clark et al. [83] reported that as patients presented with multiple co-morbidities, specialists and nurse practitioners (providing care for people with osteoporosis) experienced "guideline overload" (p. 1957) and lacked self-efficacy (and knowledge) to effectively navigate the multiple disease-specific exercise guidelines to confidently prescribe exercise EBIs. • Self-efficacy is an identified barrier to exercise engagement and an established correlate of adult physical activity levels [84]. As such, addressing self-efficacy is a core component of exercise EBIs (both for exercise EBIs as an intervention to promote patient behaviour change and for healthcare providers to support referrals processes).
Individual stages of change Characterization of the phase an individual is in, as he or she progresses toward skilled, enthusiastic, and sustained use of the intervention*.	• The American College of Sports Medicine provides comprehensive recommendations for delivering exercise EBIs as part of the treatment for chronic diseases, including individual behavioural techniques. This determinant could equally be applied to health professionals to determine their readiness to engage with the exercise EBI.
Individual identification with the organisation A broad construct related to how individuals perceive the organization, and their relationship and degree of commitment with that organization*.	• Furness and colleagues [68] highlighted the issue of a misalignment between the organisation's values and that of individual staff. The study, which focused on adding an exercise physiologist to an existing mental health care team, quoted management as saying they had a direction for the service that was about "health promotion" (p. 122). However, a senior staff member noted, "people are going well why are we spending money on that role as opposed to more nurses?" (p. 124).
Other personal attributes A broad construct to include other personal traits such as tolerance of ambiguity, intellectual ability, motivation, values, competence, capacity, and learning style*.	• *Other personal attributes* is a broad construct that includes a range of personal factors known to influence implementation, such as motivational levels, learning style, and personal values [18]. Young et al. [70] noted that staff perceptions about their professional role and identity might influence the implementation of exercise EBIs in diabetes care; however, this is an area of little research [47].
CFIR = Consolidated Framework for Implementation Research, EBI = Evidence-base Intervention, GPs = General Practitioners, * = definitions as supplied by the CFIR companion website https://cfirguide.org/constructs/	

4.5 CFIR Domain - The process of implementation

The determinant constructs listed within this domain include [18]: 1) planning; 2) engaging (that includes opinion leaders, formally appointed internal implementation leaders, champions and external change agents); 3) executing; and 4) reflecting and evaluating. *Planning* for implementation generally involves identifying the barriers and enablers to implementation and designing and enacting implementation strategies to address barriers and leverage enablers. This may also involve some form of iteration or evaluation to optimise implementation [21]. The 'Together in Movement and Exercise' [85] planned for the expansion of a community-based exercise program for people with neurological conditions before implementation. The planning process matched specific implementation strategies to each identified barrier. This approach to planning offers a sound model for other exercise EBI to replicate, as tailoring implementation strategies to specific barriers is an identified need of implementation research [86]. Table 5 provides examples of how the *Process of Implementation* may apply to exercise EBI.

Table 5: The CFIR domain of the *Process of implementation*: Determinant constructs and descriptive examples from the exercise literature

Determinant Constructs and definitions from the CFIR companion website [47]	**Descriptive examples from the exercise literature**
Planning The degree to which a scheme or method of behavior and tasks for implementing an intervention are developed in advance, and the quality of those schemes or methods*.	• In diabetes care, a plan-do-study-act (PDSA) cycle was used to develop a diabetes care program that included exercise within an existing health service. Multiple iterations of the PDSA cycle were untaken before patients were enrolled in the program to ensure barriers to successful implementation were addressed [87]. • Finlayson and colleagues [88] used the RE-AIM framework to plan and design recommendations for fall prevention programs in people with multiple sclerosis. They used the framework to develop practical considerations that organisations should consider within their planning to improve programs' reach, adoption, implementation, and maintenance.

	• Koorts and colleagues [89] have developed a practical guide based on the CFIR (and two other frameworks) that can be used to plan for implementing exercise EBIs in healthcare settings.
Engaging Attracting and involving appropriate individuals in the implementation and use of the intervention through a combined strategy of social marketing, education, role modelling, training, and other similar activities*.	• Four sub-sections describe how individuals can be engaged in the implementation process (opinion leader, formally appointed internal implementation leader, champion, external change agent). • In cardiac rehabilitation, the cardiologist's role in setting up the initial appointment was viewed as an incentive to participate by patients [49]. • Kimmel et al. [90] suggested that physicians are the most "powerful influencers" (p. 154) in getting people with cancer to adopt lifestyle behaviours, including exercise EBIs. • Granger et al. [57] suggested that due to the value patients placed on medical practitioners advice, they needed to promote exercise EBI (in addition to other health workers). Further, the role of the champion in supporting the implementation of exercise EBIs has been identified as necessary in mental healthcare [54] and cancer care [80]. • Beidas and colleagues [51] reported that the role of the champion in exercise oncology was: 1) to encourage buy-in of the program; 2) to adapt the referral and program protocols; and 3) to support other staff through the implementation process. Finally, this same study quoted an oncology provider as saying, "Selling this idea is going to have to be done by some external force and all we can do is cooperate and buy-in and go along with it. It will be much more efficient I think" (p. 343). This suggests that the oncology staff may have welcomed an external driver (i.e., external change agent) of the exercise EBI.
Executing Carrying out or accomplishing the implementation according to plan*.	• Hoekstra and colleagues [91] reported that an implementation strategy used to implement an exercise EBI in disability care was to support organisations in writing project plans and reporting requirements that were reviewed during the execution of implementation. • Other studies identified implementation strategies used to enable implementation but did not advise if these were part of a broader implementation planning and *execution*. For example, Santa Mina and colleagues [25] reported that implementation strategies used to generate support for implementing exercise in cancer care included hosting

	interprofessional workshops and presentations at clinical rounds and departmental meetings. Mewes et al. [92] reported that many implementation strategies were clinically and cost-effective in increasing compliance with exercise guidelines in cancer care.
Reflecting and evaluating Quantitative and qualitative feedback about the progress and quality of implementation accompanied with regular personal and team debriefing about progress and experience*.	• Lederman and colleagues [54] identified program evaluation as a central strategy that enabled understanding of “what works in real-world clinical settings” (p. 4). • Gyurcsik and Bittain [93] evaluated the implementation of a community-based exercise EBI for people with arthritis (PACE®). The evaluation found that despite provider support, the program had poor participation and many organisations ceased offering the program. At all sites where implementation failed, providers were sent to PACE® training by their employer. This suggests a possible mismatch between PACE® and *patient needs and resourcing*, as local community members did not take up the program. • Stoutenberg and colleagues [61] provided an evaluation framework that documents the metrics that could reasonably be collected in routine healthcare systems to evaluate the effectiveness of exercise EBIs.

CFIR = Consolidated Framework for Implementation Research, EBI = Evidence-based intervention, RE-AIM = Reach, Effectiveness, Adoption, Implementation, Maintenance framework, PACE® = People with Arthritis Can Exercise, * = definitions as supplied by the CFIR companion website https://cfirguide.org/constructs/

5. Recommendations

Recently the research-to-practice gap in non-pharmacological EBIs (such as exercise) has been identified as an explicit opportunity to capitalise on research outputs [29]. The justification is that non-pharmacological EBIs can be just as effective as their pharmacological equivalents [29]. However, as demonstrated through this article, successfully implementing interventions that show efficacy is challenging and complex, with multiple determinants acting as potential barriers to the implementation process.

The authors suggest there is great scope to augment exercise EBI research with identified priorities from implementation science to improve research translation into practice [86, 94, 95, 52]. First, researchers are encouraged to embrace research designs that better address the nuances associated with optimising real-world health services [32]. For example, this includes conducting pragmatic trials that assess the effectiveness of exercise EBIs whilst simultaneously offering a rich description of the determinants that influenced implementation. Pragmatic trials need to be accompanied by research that explores how the organisational culture enables the uptake of exercise EBIs (*culture*), specifies whether incentives or policies existed that were leveraged to advance implementation efforts (*policies and incentives*) and articulates how stakeholders have been engaged through the implementation process and the outcomes of these efforts (*engaging*). Improving reporting on determinants also aligns with the UK Medical Research Council guidance for evaluating complex interventions in healthcare. The guidance recommends that evaluations consider the contextual factors that affect implementation or the mechanisms by which the EBI works [96].

Second, developing knowledge about how exercise EBIs are adapted during the implementation process is recommended. Whilst poor reporting of exercise EBI protocols is an identified barrier to implementation [97] and standardised reporting guidelines have been developed [98], adaption to standardised protocols is likely to occur during implementation. Identifying adaptions made to the exercise EBI and evaluating what level of adaption is acceptable [52] without comprising the clinical effectiveness of the EBI are needed. Adaptions may include changes to delivery mode, supervision levels, frequency, duration or intensity of the intervention, or staff from different roles delivering the intervention. A recently published systematic review of obesity interventions that quantified the scale-up penalty (defined as the reduction in effect size that occurs when implementing interventions in real-world environments) found that all interventions were adapted before implementation and the scaled-up interventions demonstrated less than 75% of the effects than had been previously established in efficacy trials [99]. In some cases, the effects were as low as 25% [99].

The final recommendation where implementation science could improve the translation of exercise EBI is through evaluating those implementation strategies, or combination of strategies, that are most effective to enhance the uptake of exercise EBIs. This includes understanding the mechanisms behind how and why the implementation strategy works [86] and specifying implementation strategies [95]. Particularly useful for exercise EBIs would be testing how different implementation strategies can lead to not only initial implementation but to ongoing, sustainable change in routine practice. To illustrate, the lack of healthcare provider knowledge about the benefits of exercise is a barrier to implementing exercise EBIs. Conversely, healthcare providers were also seen as opinion leaders and champions that could positively influence the uptake of exercise EBIs. Applicable to a broad range of exercise EBIs would be designing and testing targeted, cost-effective strategies that work across multiple settings and are sustained over time [86].

As most healthcare organisations have finite resources, optimising investment by resourcing those implementation strategies that are shown to be effective for integrating exercise EBIs in routine practice is likely to be appealing. A study by Grace and colleagues [64] explored the effectiveness of different implementation strategies designed to increase referrals and uptake of cardiac rehabilitation programs. The results demonstrated that uptake significantly improved by using strategies such as booking appointments before discharge, implementing automatic referrals and providing patient education shortly after discharge, by a two to five-fold effect. Thus, we recommend that implementation research in the exercise setting examine the transferability of such strategies.

We suggest that researchers defer to existing taxonomies of implementation strategies that are described in sources such as the Expert Recommendations for Implementing Change (ERIC) project (which identified 73 implementation strategies) [37], the Effective Practice and Organisation of Care (EPOC) [100] and Behaviour Change Techniques (BCT) as outlined by Michie et al. [101]. Whilst the BCT has been recommended [102] to support the identification of components of physical activity interventions associated with effectiveness, such as social support, self-monitoring, goal setting and feedback, the distinction must be drawn between this and the components of the implementation strategy. That is, what are the effective components of implementation strategies, and how do they exert their influence to successfully implement exercise EBI? Powell and colleagues [103] also provide helpful guidance for selecting and tailoring implementation strategies. In sum, we currently have a limited understanding of implementation strategies and integrating exercise EBI in routine practice.

5. Conclusion

By exploring the exercise EBI literature aligned to the CFIR, we aimed to illustrate the breadth of determinants that influence implementation. There are limitations to this approach, including that we did not conduct a systematic review to identify studies that aligned with the CFIR. However, we sought to include a range of EBI literature that best illustrates the 39 determinant constructs. Despite these limitations, by highlighting the inherent relationship between the proximal identification of determinants and the distal outcome of successful implementation, we offer recommendations that leverage current implementation science priorities [86, 52, 94, 95] to help bridge the research-to-practice gap in exercise EBIs. Implementation science provides an opportunity to expand the research agenda, reduce research waste and increase the relevance of exercise EBI research. Without a greater emphasis on implementation research, much of the resources spent proving the efficacy of exercise EBIs will be wasted as we fail to apply this knowledge in real-world settings.

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2.3 Concluding statements - Section 1 (chapters 1 and 2)

Chapter 1 introduced the history and core concepts of implementation science and exercise EBIs, mental illness and cancer. In Chapter 2, we conducted a global search, guided by the CFIR, to understand how the determinants that influence implementation are described in the exercise EBI literature. Despite implementation science now entering its third decade, the results of the literature review suggest there is a significant opportunity to apply learnings from implementation science to advance exercise EBI uptake and use in practice for treating NCDs. Several recommendations are offered, including the need for more pragmatic research that captures the context of implementation and the adaption/fidelity nexus and better tracking and reporting of implementation strategies.

Pragmatic research designs include synthesis methods that may better inform implementation practice. In the next section of this thesis, two studies are conducted that encourage reflection on the extant evidence base in exercise EBIs and mental illness and cancer, with a lens on pragmatic application. The studies adopt innovative evidence synthesis methods to demonstrate how these methods can improve the use of evidence in practice. This includes methods that can begin to capture the adaption/fidelity nexus and context of implementation.

3.0 CHAPTER THREE: Health benefits, safety and cost of physical activity interventions for mental health conditions: A meta-review to inform translation efforts

3.1 Preamble

The previous section highlighted the potential for implementation science to improve the uptake and use of exercise EBIs in healthcare settings by, for example, using innovative evidence synthesis approaches that may be better suited to implementation. In Section 2 of this thesis (chapters 3 and 4) innovative methods are applied to address the first of two sub-aims that comprise the overall body of work. The sub-aim explored through this section is:

- *Conduct novel evidence synthesis of exercise EBIs for mental illness and cancer to understand how different synthesis methods can support improved implementation in practice.*

This chapter details a meta-review that explored the effectiveness of exercise EBIs, when applied as a treatment for various mental illnesses. The outcomes of interest were identified as outcomes that are considered important in real-world healthcare practice (i.e., expected health benefits, intervention safety and cost).

This work has been published:

3.2 Published manuscript

Czosnek L, Lederman O, Cormie P, Zopf E, Stubbs B, Rosenbaum S. Health benefits, safety and cost of physical activity interventions for mental health conditions: A meta-review to inform translation efforts. *Mental Health and Physical Activity*. 2019 March;16:140-151. doi.org/10.1016/j.mhpa.2018.11.001.

The supplementary files accompanying this publication are supplied in the thesis Appendix.

Update

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BMC Cancer

RESEARCH ARTICLE

Open Access

Exercise interventions for people diagnosed with cancer: a systematic review of implementation outcomes

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Abstract

Purpose: Exercise is efficacious for people living after a cancer diagnosis. However, implementation of exercise interventions in real-world settings is challenging. Implementation outcomes are defined as 'the effects of deliberate and purposive actions to implement new treatments, practices, and services'. Measuring implementation outcomes is a practical way of evaluating implementation success. This systematic review explores the implementation outcomes of exercise interventions evaluated under real-world conditions for cancer care.

Methods: Using PRISMA guidelines, an electronic database search of Medline, PsycInfo, CINAHL, Web of Science, SportsDiscus, Scopus and Cochrane Central Registry of Controlled Trials was conducted for studies published between January 2000 and February 2020. The *Moving through Cancer* registry was hand searched. The Implementation Outcomes Framework guided data extraction. Inclusion criteria were adult populations with a cancer diagnosis. Efficacy studies were excluded.

Results: Thirty-seven articles that described 31 unique programs met the inclusion criteria. Implementation outcomes commonly evaluated were *feasibility* (unique programs *n* = 17, 54.8%) and *adoption* (unique programs *n* = 14, 45.2%). Interventions were typically delivered in the community (unique programs n = 17, 58.6%), in groups (unique programs *n* = 14, 48.3%) and supervised by a qualified health professional (unique programs *n* = 14, 48.3%). Implementation outcomes infrequently evaluated were *penetration* (unique programs n = 1, 3.2%) and *sustainability* (unique programs n = 1, 3.2%).

Conclusions: Exercise studies need to measure and evaluate implementation outcomes under real-world conditions. Robust measurement and reporting of implementation outcomes can help to identify what strategies are essential for successful implementation of exercise interventions.

Implications for cancer survivors: Understanding how exercise interventions can be successful implemented is important so that people living after a cancer diagnosis can derive the benefits of exercise.

Keywords: Exercise, Implementation outcomes, Cancer, Physical activity, Systematic review

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Background

Cancer is a leading cause of disease burden worldwide. In 2020, 19.2 million new cases of cancer and 9.9 million cancer-related deaths occurred globally [1]. Cancer rates are projected to rise steadily in the coming decades, in part due to population growth, ageing and more people surviving a cancer diagnosis because of improvements in early detection and treatment advances [2, 3].

Exercise is important in addressing the sequala of disease and impacts of a cancer diagnosis, as demonstrated in the robust efficacy base of systematic reviews, meta-analyses and meta reviews [4–11]. High quality or 'level one evidence', as gathered through systematic reviews and meta-analyses, informs the development of clinical practice guidelines (CPGs). CPGs are evidence-based statements that include recommendations to optimise patient care [12]. In 2019, the American College of Sports Medicine (ACSM) updated evidence-based advice for cancer and exercise testing, prescription and delivery in cancer survivors. The consensus statement provides exercise prescription recommendations for common cancer-related health outcomes including depression, fatigue and quality of life [13]. The ACSM is one of many organisations worldwide that recommend exercise be incorporated within the routine care for people with cancer [14–17].

The development of CPGs, whilst fundamental to informing evidence-based care, is unlikely to directly change clinical practice [18]. To facilitate the implementation of their consensus statement, ACSM published additional resources describing *how* implementation can be fostered [19] and created the *Moving through Cancer* registry to connect people with cancer to local exercise services [20]. This signifies greater attention to translating research findings into practice and moving beyond demonstrating exercise efficacy for different cancer types.

Most research that establishes the efficacy of health interventions is conducted in tightly controlled research settings, focusing on internal validity [21, 22]. Efficacy studies exclude many participants in an attempt to recruit a homogenous sample. Such research studies are often well funded and have access to the required resources needed to deliver the evidence-based intervention, health program or innovation (hereafter 'intervention') with high fidelity to the described study protocol. Further, research staff often take part in extensive training sessions to deliver the intervention [23, 24]. These conditions rarely reflect the conditions under which an intervention is implemented in healthcare settings. That is, staff may have limited time to instruct patients during clinical consultations, inadequate training to prescribe exercise interventions or insufficient physical space to establish an exercise intervention [25]. It is common for efficacious interventions to fail in practice [26] or have reduced clinical impact when replicated to reach more of the population for which they are intended [27, 28]. Pragmatic study designs seek to address these issues through answering the question "Does this intervention work under usual conditions?" [29]. That is, they seek to reflect population diversity in study samples and explore whether it is realistic to implement the intervention. Despite the growth in cancer studies about exercise in recent years, relatively little is known about the outcomes of exercise interventions when implemented using pragmatic study designs, or the 'external validity' of how best to implement and evaluate exercise interventions in practice [22].

Proctor and colleagues [30] have developed an Implementation Outcomes Framework to evaluate implementation success. If implementation is successful, the proposed theory of change suggests this contributes to desired clinical or health service outcomes (e.g., a safe, efficient service that successfully addresses patient symptomology). Evaluating the outcomes of implementation efforts can also reduce the risk of incorrectly concluding that an intervention is ineffective, when in fact, poor implementation may be the most significant contributor to failure [30, 31]. Implementation science frameworks that evaluate implementation outcomes may therefore be useful to determine whether failure is due to the intervention or the implementation process [32, 33]. Proctor and colleagues [30] define eight implementation outcomes for this purpose: acceptability, adoption, appropriateness, cost, feasibility, fidelity, penetration and sustainability.

The Implementation Outcomes Framework was used to inform the outcomes of interest for this review. The aim of this review was to examine the implementation outcomes that are evaluated under real-world conditions when exercise interventions are implemented for the care of people diagnosed with cancer.

Table 1 provides a description of how the implementation outcomes were operationalised in this study.

Methods

Protocol and registration

This review was registered in the PROSPERO database (CRD42019123791) and conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [34].

The search strategy was developed in consultation with a librarian experienced in systematic reviews. First, the search strategy of a recent meta-review that summarised the efficacy of exercise and cancer was replicated and augmented with additional search terms for exercise (e.g., physical activity) [5]. Second, this search was combined with terms derived from the Implementation Outcomes Framework (e.g., adoption, acceptability) [35]. Finally, the reference list of relevant articles and the *Moving through Cancer* program registry were also screened to identify potentially relevant studies [20, 36,

Table 1 Operational definition of implementation outcomes applied in review

Implementation outcome	Proctor et al. definitions of outcomes [29]	Operational definition as applied in this review
Acceptability	The perception among implementation stakeholders that a given treatment, service, practice, or innovation is agreeable, palatable, or satisfactory.	The degree to which the patient or healthcare workforce find the exercise intervention satisfactory as measured by the patient or healthcare workforce.
Adoption	The intention, initial decision, or action to try or employ an innovation or evidence-based practice	Any measure that reports on the uptake of exercise intervention as reported by the healthcare staff (for example, total number of staff making referrals to exercise) or organisation; this may include barriers and enablers.
Appropriateness	The perceived fit, relevance, or compatibility of the innovation or evidence-based practice for a given practice setting, provider, or consumer; and/or perceived fit of the innovation to address a particular issue or problem.	Exercise interventions are implemented because there is a specific, documented rationale that indicates the intervention is relevant to that patient population, based on clinical trials effectiveness (for example, reference to a successful efficacy trial that the current exercise intervention is based upon).
Cost	Cost (incremental or implementation cost) The cost impact of an implementation effort according to three components: i) cost of delivering the intervention, ii) cost of the specific implementation strategy and iii) the delivery cost according to the setting	The documented cost of implementing the exercise intervention in healthcare settings. This includes costs incurred by healthcare organisations such as human and physical/practical resources, or costs associated with use of the intervention.
Feasibility	The extent to which a new treatment, or an innovation, can be successfully used or carried out within a given agency or setting	Intervention attendance and/or attrition rates for the program.
Fidelity	The degree to which an intervention was implemented as it was prescribed in the original protocol or as it was intended by the program developers	The exercise intervention is delivered as described in the documented pre-implementation plan or intervention protocol; if adaptations (tailoring) are required, these are reported either qualitatively or quantitatively.
Penetration	The integration of a practice within a service setting and its subsystems	Patients referred to the intervention reported with consideration to total eligible patient population (for example intervention reach data).
Sustainability	The extent to which a newly implemented treatment is maintained or institutionalized within a service setting's ongoing, stable operations	Documented evidence that the exercise intervention has been integrated within normal organisational operations (for example, reference to polices, hiring staff, documented care pathways) **and** the long-term (> 12 months) health outcomes of the exercise intervention on adverse treatment-related side effects (such as fatigue, quality of life, physical function and/or symptoms of depression). Whilst Proctor and colleague's definition of sustainability does not include a measure of clinical effect, it is added as a secondary outcome in this review. This decision was made to confirm that the exercise intervention continues to deliver the intended health benefits that it was implemented to address.

37]. The *Moving through Cancer* registry website was selected for screening because it provides a comprehensive and publicly accessible database that details established exercise interventions for people diagnosed with cancer and supports the implementation of the ACSM recommendations. Details of the search strategy are provided in Supplementary Table 1.

An electronic database search was conducted from January 2000 to 6 February 2020 (Medline, PsychInfo, CINAHL, Web of Science, SPORTDiscus, Scopus and Cochrane Central Register of Controlled Trials). Two reviewers (LC, JR) independently completed the title and abstract screening and full text review. Disagreements were resolved through discussion until a consensus was reached. Where agreement was unable to be reached, a third reviewer was available to inform the final decision (EZ). Covidence software was used to manage the screening and data extraction process [38].

Definition of terms

Physical activity is defined as "any bodily movement produced by skeletal muscles that requires energy expenditure" [39]. Exercise is "a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness" [39].

Inclusion and exclusion criteria

The inclusion and exclusion criteria for this review are summarised in Table 2. All types of physical activity and/or exercise (for example, aerobic, resistance, yoga, tai chi, Pilates, high intensity interval training) were included in the review. There were no restrictions placed on moderators of exercise (for example, supervised and unsupervised, home-based, and community/hospital-based settings, group and individual classes, face-to-face and virtual [online/video]). Further, any studies at translational stages prior to and including efficacy studies were excluded. As such, studies described as effectiveness or implementation/dissemination were included. Definitions for the categorisation of studies is supplied in Supplementary Table 2.

Data extraction and quality assessment

A data extraction tool was developed with reference to the published literature [41]. One author (LC) extracted data on: study type (effectiveness or implementation/dissemination study), implementation outcome, the level at which the implementation outcome was measured (patient, provider, intervention, organisation or a combination) and the exercise intervention composition and setting [19]. The Consensus on Exercise Reporting Template (CERT template) provides reporting recommendations and was used to detail the composition of exercise interventions [42].

Study quality was assessed using one of two tools. The Joanna Briggs Institute (JBI) suite of Critical Appraisal Tools were used to assess quality in quantitative and qualitative studies (the relevant JBI tool was selected for each study based upon the study design) [43]. The Mixed Methods Appraisal Tool was used to critically appraise studies that described a mixed method design [44]. The outcomes of the quality assessment are provided in Supplementary Table 3. An independent compliance check of data extraction and quality assessment was completed by two authors (NR, EZ) for 10% of the included studies.

Table 2 Inclusion and exclusion criteria for the systematic review

Inclusion criteria
• Studies where an exercise intervention was offered alongside cancer care within the continuum from diagnosis to treatment with curative intent and through to survivorship
• Studies that included people aged 18 years or older with a confirmed diagnosis of cancer
• Studies that reported at least one implementation outcome, as per the operational definition
Exclusion criteria
• Non-human studies
• Studies not published in English
• Efficacy trials (defined according to an established classification) [40] (refer to supplementary Table 2 for expanded definitions and categorisations applied in this review)
• Studies involving patients undergoing end-of-life care (for example, palliative care)
• Studies involving exercise interventions designed to prevent or reduce the risk of developing cancer
• Intervention studies where exercise interventions were included within a broader healthy lifestyle program and the independent effects of exercise could not be extracted
• Studies that did not describe an active intervention
• Studies that describe the methodological development or testing of an instrument to measure efficacy of an exercise intervention

Data synthesis and analysis

The Implementation Outcomes Framework guided the initial data synthesis [30]. Data were extracted, collated and analysed based upon the eight implementation outcomes. Quantitative and qualitative results were extracted and analysed concurrently and integrated to produce the final synthesis. Descriptive statistics and frequencies (using the total possible number of outcomes as the denominator) were calculated to synthesise the study type and the total number of implementation outcomes explored in the included studies.

Results

Search results

A total of 7123 articles were identified through the database search. After de-duplication, 4563 articles remained and 11 additional citations were identified through the manual search of reference lists and the *Moving through Cancer* exercise program registry [45–55]. After full text screening, 37 articles were included in the final review, which represented 31 unique programs. Descriptive statistics reported within the manuscript reflect outcomes for unique programs. Figure 1 presents a flow diagram for the results. Supplementary Table 4 provides a list of studies that were excluded after full text review and reasons for exclusion.

Table 3 provides a summary of the characteristics of the studies that met the inclusion criteria.

A collated summary of the included studies is provided in Table 4 and highlights the diversity in study design and composition of exercise interventions. Most interventions (n = 26, 89.7%) included a combination of aerobic, resistance and stretching exercises. Interventions were most often delivered to people with any cancer type (n = 16, 55.2%), using a group-based structure (n = 14, 48.3%), supervised by a qualified health professional (physiotherapist, exercise physiologists) (n = 14, 48.3%) and based in a community setting (n = 17, 58.6%). Of the 58.6% of programs that were based in the community,

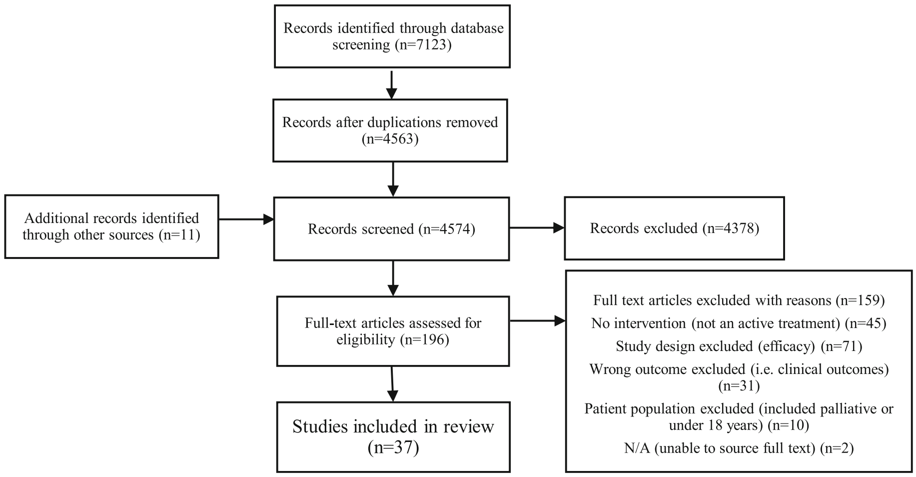

Fig. 1 PRISMA Diagram

27.6% ($n = 8$) were in specialist exercise clinics and 24.1% ($n = 7$) were in fitness centres and 6.9% ($n = 2$) used a combination of specialist clinics and fitness centres. Definitions for the settings are supplied in Table 3.

The results for each implementation outcome and study type are summarised in Table 5. The most common implementation outcomes assessed were *feasibility* ($n = 17$, 54.8%) and *adoption* ($n = 14$, 45.2%) of exercise interventions. The most common classification was effectiveness study ($n = 15$, 48.4%).

The results are expanded upon in Supplementary Table 5 and below.

Acceptability

Six studies reported on the acceptability of exercise interventions for people with cancer, measured at the patient-level [53, 67, 70, 73, 76, 77]. Patient satisfaction (variously defined as enjoying the program, finding the program useful/valuable) was generally high, with five studies reporting acceptability levels above 80% [53, 70, 73, 76, 77]. None of the included studies reported on the acceptability of exercise interventions measured at the healthcare professional level.

Adoption

Fourteen studies reported on exercise intervention adoption [49, 50, 55, 56, 58, 61, 63, 65, 69, 74–77, 81]. Nine studies assessed qualitative barriers and enablers to intervention adoption (refer to supplementary Table 5) but did not measure adoption [50, 55, 56, 61, 69, 74–76, 81]. Four studies explored uptake by organisations [49, 63, 65, 77] and one study assessed both organisational uptake and qualitative barriers to adoption [58]. Of the five studies that measured adoption, two reported the percentage of organisations across the country who had adopted exercise oncology programs, with 60% of hospitals in Belgium adopting programs and 18% of YMCA's in America delivering a specific program (i.e., Livestrong at the YMCA). The three further studies that measured organisation adoption rates provided the raw number of organisations delivering a program, without reference to total possible delivery organisations (i.e., 40 sites across Australia). None of the identified studies reported on overall program uptake rates by healthcare providers, such as the total number of professionals making patient referrals to exercise.

Appropriateness

Thirteen studies reported on the appropriateness of exercise interventions [45, 48, 51, 53, 56, 57, 62, 67, 68, 74, 76, 79, 80], representing 11 unique programs. Six studies [45, 51, 56, 57, 62, 74] reported that appropriateness was established by testing the efficacy of the exercise intervention in the target population (in a previous efficacy trial). Five studies [48, 67, 68, 79, 80] reported using multiple data sources (including a literature review, reference to established models of care and/or review of barriers and enablers) to establish appropriateness, with only two of these studies directly engaging with program staff through the development phase [48, 80]. Two studies stated a phased approach to implementation (a pilot period completed prior to full intervention roll-out) was undertaken to establish appropriateness of the intervention [53, 76].

Cost

Twelve studies reported on costs associated with implementation [45, 48, 56, 60, 61, 63, 65–67, 72, 74, 75], representing 11 unique programs. Two studies estimated the intervention implementation costs in the set-up year (e.g., purchase of computers and equipment, cleaning, personnel), stating that it cost \$US44,821 and \$US46, 213, respectively [45, 67]. One study reported the

Table 3 Characteristics of included studies

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
Beidas	2014	Effectiveness/ Implementation	*n* = 84 (effectiveness) *n* = 19 (implementation)	Adoption Appropriateness Cost	Healthcare Provider Intervention Intervention	Community (specialist exercise clinic) + Home	Breast cancer	What (materials) - Power blocks adjustable dumbbells Who (qualifications) – Physiotherapist How (delivery) - One physiotherapist to 7 or fewer survivors; Exercise logs used for self-reported adherence monitoring When, how much (dosage) - 4 small group PT sessions completed over 1–2 months + 2x/wk. home resistance training Tailoring – Individualized
Bjerre	2018	Effectiveness	*n* = 214 (*n* = 109 intervention *n* = 105 control)	Appropriateness Cost Feasibility Fidelity	Intervention Intervention Patient Healthcare provider	Community (fitness centre)	Prostate cancer	What (materials) – Not reported Who (qualifications) – Local football coaches who underwent 8–10 h of training in intervention and cancer How (delivery) – Group football training When, how much (dosage) - 6 months of recreational football for 1 h 2x/wk. Football sessions lasted 1 h and included 20 min of warm up and 20 min each of drills and match play
Bjerre	2019	Effectiveness	n = 214 (n = 109 intervention n = 105 control)	Appropriateness	Intervention	Community (fitness centre)	Prostate cancer	See Bjerre 2018
Bultijnck	2018	Implementation	*n* = 98	Adoption	Organisation	Hospital (not stated if inpatient or outpatient)	Prostate cancer	Characteristics of exercise program were reported for general cancer rehabilitation programs and prostate cancer specific programs. Below is a summary of both program types: General What (materials) – NA Who (qualifications) - NA How (delivery) - 73.3% were group training, 57.8% started after treatment When, how much (dosage) - Most programs included aerobic and resistance components of between 60 and 90 min duration conducted 2x/wk. 42.2% of programs conducted 24 sessions. Tailoring - NA Prostate cancer specific programs What (materials) – NA Who (qualifications) - NA How (delivery) - 77.8% were group training, 38.9% started during treatment When, how much (dosage) - 100% of programs included aerobic and resistance components and approx. Half also included flexibility and pelvic training, 50% were 90 min in duration and most commonly conducted 2x/wk. 61.1% of programs conducted 48 sessions. Tailoring - NA

Table 3 Characteristics of included studies *(Continued)*

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
Brown	2019	Effectiveness	*n* = 183	Feasibility Fidelity	Patient Healthcare provider	Community (specialist exercise clinic)	Any cancer type	What (materials) - Treadmill, cycle ergometer, NuStep, Aquaciser (underwater treadmill), and outdoor walking or jogging. Cybex® resistance machines, resistance bands, dumbbells, medicine balls, body weight, and resistance tubing Who (qualifications) – Certified Clinical Cancer Exercise Specialists (CCES) How (delivery) - Individual sessions When, how much (dosage) - Each phase (a total of 3 phases + 1 phase of infinite duration) was 3x/wk. for 12 wks. Duration was 60 min per session (20 min aerobic, 30 min resistance (3 × 10 reps), 10 min for flexibility training, and balance exercises incorporated throughout. Intensity increased from low/ mod to high as Phases progressed. Tailoring - Individualized based on patient assessment
Cheifetz	2014	Effectiveness/ Implementation	*n* = 115 (effectiveness)	Fidelity Feasibility	Healthcare Provider Patient	Community (fitness centre)	Any cancer type	What (materials) -Not reported Who (qualifications) - YMCA staff who undergo specific training lead by physiotherapist or nurse How (delivery)- Group training, peer support encouraged When, how much (dosage) - 12 wk. program, 2x/wk. supervised + 1x/wk. independent exercise. Includes aerobic (target HR 50–80% MHR), muscle strength (2–3 sets, 12 repetitions) and flexibility based on established guidelines (i.e. ACSM) Tailoring - Programs are tailored and individualized on the basis of baseline testing, unique cancer type and stage and person specific precautions and contraindications.
Cheifetz	2015	Effectiveness/ Implementation	*n* = 57 (effectiveness) *n* = 12 (implementation)	Feasibility	Patient	Community (fitness centre)	Any cancer type	See Cheifetz 2014
Culos-Reed	2018	Effectiveness/ Implementation	*n* = 58 (effectiveness)	Appropriateness Cost Feasibility Fidelity	Intervention Intervention Patient Healthcare Provider	Community (specialist exercise clinic and fitness centre)	Prostate cancer	What (materials) -Exercise that can be completed with minimal equipment (exercise bands and balls, body weights and free weights) Who (qualifications) - Credentialed health and fitness professionals How (delivery)- Group training. Maximum ratio 1 facilitator per 15 participants. When, how much (dosage) - 12-wk program (with an additional 12-wk maintenance phase), 60 min per session, completed 2x/wk. of 1-h duration. A combination of mild to mod/somewhat hard-intensity aerobic and resistance training, or gentle yoga with cool-down and meditation (i.e. savasana). Group exercise consists of 3–4 exercises in a circuit with adapted plyometric aerobic exercise.

Table 3 Characteristics of included studies *(Continued)*

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
								Tailoring - All exercises are adapted to accommodate individuals' preferences and limitations
Culos-Reed	2019	Implementation	n = 11	Cost	Intervention	Community (specialist exercise clinic and fitness centre)	Prostate cancer	See Culos-Reed 2018
Dalzell	2017	Implementation	*n* = 1635 (referred over the duration)	Adoption Cost	Organisation Organisation	Hospital (out-patient) + Community (specialist exercise clinic) + Home	Any cancer type	What (materials) - Not reported Who (qualifications) - Varied depending upon triage of patients How (delivery)- Varied depending upon triage of patients When, how much (dosage) - ACSM exercise guidelines for cancer survivors and included components of flexibility, cardiovascular, and resistance training whenever possible. Focused on increasing physical activity levels and included a combination of home exercise, wellness centre–based training, or participation in exercise classes. Tailoring – Individualized programs with re-assessment every 3 months.
Dennett	2017	Implementation	*n* = 31 (exercise oncology programs) n = 15 (providers)	Adoption	Healthcare Provider	Hospital (in and outpatient) + Community (specialist exercise clinic)	Not reported	What (materials) - Not reported Who (qualifications) - Supervised (by physiotherapists or exercise physiologists) How (delivery) - Typically conducted in a group based upon an initial individualized assessment. When, how much (dosage) - Included aerobic, resistance and flexibility exercises. Exercise outside the program was encouraged with most suggesting aerobic exercise 4-5x/wk. and resistance exercise 2-3x/wk. Strategies used to encourage compliance with home exercise included written home exercise programs and referrals to community groups. Tailoring - Programs are typically individualized, monitored throughout and progressed.
Dolan	2018	Effectiveness	*n* = 152 (files)	Appropriateness Feasibility	Intervention Patient	Community (specialist exercise clinic)	Breast cancer	What (materials) - free weights, body weight, and/or elastic bands Who (qualifications) - cardiac rehabilitation supervisor + 2 exercise assistants How (delivery)- Group program (15 patients) When, how much (dosage) - supervised exercise (dynamic warmup, aerobic training (walking commence at 1 mile and increase to 3 miles (walk/jog) starting at 60%VO_2 reserve with fitter individuals starting at 80%VO_2 reserve), strength training (2 × 10 reps of 12 full-body exercises), and cool-down) with 12 education seminars. 22 sessions 1x/wk. for the duration of the program. In addition to

Table 3 Characteristics of included studies *(Continued)*

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
								the weekly supervised exercise session, unsupervised activities (up to 2 strength and 4 aerobic sessions /wk) were promoted through education and goal setting. Peer mentoring supported Tailoring - Individualized according to current guidelines and initial baseline fitness test results
Haas	2011	Implementation	NA	Adoption Cost Feasibility	Organisation Organisation Patient	Community (fitness centre)	Any cancer type	What (materials) - Dumbbell weights Who (qualifications) - unclear - clinical personnel complete initial assessment How (delivery) - Unclear When, how much (dosage) - Aerobic exercise, stretching, upper body weight-lifting exercises + 1 core exercise (squats or stability ball). Activity plan developed and a follow-up exercise schedule established. Participants are encouraged to exercise at least 3x/wk. and increase exercise intensity or duration by 10 to 15% each wk. Tailoring - Individualized according to current guidelines and initial baseline fitness test results. Activity is ceased during sessions on self-reported mild fatigue
Haas	2012	Effectiveness	$n = 177$	Feasibility Sustainability	Patient Patient + Organisation	Community (fitness centre)	Any cancer type	See Haas 2011 Pedometers were provided
Heston	2015	Implementation	$n = 1591$ (providers) $n = 1668$ (participants)	Adoption Cost Feasibility Fidelity	Organisation Intervention + Organisation Patient Healthcare Provider	Community (fitness centre)	Not reported	What (materials) - Not reported Who (qualifications) - YMCA staff trained in LIVESTRONG How (delivery)- small-group (6–16 participants) When, how much (dosage) - Adheres to ACSM guidelines. 12-wk duration, 2 sessions/wk. (75 min session) including aerobic fitness, muscle mass and strength, flexibility and balance. Peer-to-peer support included. Tailoring - Instructors created individualized physical activity plan
Irwin	2017	Effectiveness	$n = 186$ ($n = 95$ intervention $n = 91$ control)	Adoption Feasibility	Organisation Patient	Community (fitness centre)	Any cancer type	See Heston 2015
Kimmel	2014	Implementation	NA	Adoption Feasibility	Organisation Patient	Community (fitness centre)	Any cancer type	See Haas 2011 After a few months move to 6 to 10 participants per staff member.
Kirkham	2016	Effectiveness	n = 163	Cost Feasibility	Intervention Patient	Hospital (out-patient)	Any cancer type	What (materials) - Nautilus system Who (qualifications) - 2 exercise physiologists + other health professional How (delivery)- Group-based When, how much (dosage) - 2 x/wk. for 12 wks (24 sessions) with optional education class 1 days per wk. Classes were 60 min in

Table 3 Characteristics of included studies *(Continued)*

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
								duration and included 20–30 min of aerobic exercise (intensity individualized but between 40 and 80% HHR) + 15–20 min of resistance exercise (8–10 reps increasing to 3 sets before increasing weights, exercise included bicep curl, triceps extension, vertical press, chest press, rows, leg extension, leg curl, leg press, lat pulldown Tailoring - Individualized as required
Kirkham	2018	Effectiveness	*n* = 73	Acceptability Appropriateness Cost Feasibility Penetration	Patient Intervention Organisation + Patient Patient Organisation	Community (specialist exercise clinic) + Home	Breast cancer	What (materials) - Treadmill, elliptical, upright or recumbent cycle ergometer, resistance machines and dumbbells, Who (qualifications) - Lead by local university (lead exercise trainer, graduate exercise trainer, volunteer kinesiology student) How (delivery)- community base program was combined with home-program When, how much (dosage) - Included aerobic and resistance exercise (e.g. press, leg curls, calf raises, chest press, and seated row on machine; triceps extensions and biceps curls using dumbbells; two core-strengthening exercises). Program commenced with supervised 3x/wk. (length of chemotherapy, plus radiation if received) then reduce to 2x/wk. for 10 wks and then 1x/wk. for 10 wks during maintenance phase. Tailoring - Individualized as required; Aerobic component commenced at 20 min and increased to 30 min duration after wk. 4 (Progressive from 50 to 70% of APMHR HRR over wks 1–8, 70–75% for wks 9). Resistance commenced at 1 × 10 and then increased to 2 × 10–12 for remaining program (Chest and leg press: 50% estimated 1-RM, Similar RPE for all other exercises Weights were progressed every 4 wks up to 75% of 1-RM).
Kirkham	2019	Effectiveness	n = 73	Appropriateness	Intervention	Community (specialist exercise clinic) + Home	Breast cancer	See Kirkham 2018
Leach	2014	Implementation	Not reported	Adoption	Organisation	Community (specialist exercise clinic) + Home	Breast cancer	What (materials) - Not reported Who (qualifications) - Initial assessment by certified exercise physiologists How (delivery) - Option of home-based or community-based (group) When, how much (dosage) - 2 days aerobic (40–60% APMHR for 20–60 min), 1 day of resistance exercise (varies between 1 and 3 sets of 8–12 repetitions and 5–14 exercises depending on difficulty level) and 5–7 days of flexibility exercise/wk. Participants are provided with 3 levels of difficulty (easy, medium, hard). Home-based exercisers are given resources that includes pictures and

Table 3 Characteristics of included studies *(Continued)*

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
								descriptions of all exercises and complete a fitness log to track adherence. Tailoring - Self-administered tailoring
Leach	2015	Effectiveness	$n = 80$	Acceptability Feasibility	Patient Patient	Community (specialist exercise clinic) + Home	Breast cancer	See Leach 2014
Leach	2016	Effectiveness	$n = 63$ (maintenance phase)	Feasibility	Patient	Community (specialist exercise clinic) + Home	Breast cancer	See Leach 2014
Mackenzie	2013	Effectiveness	$n = 66$	Appropriateness Feasibility	Intervention Patient	Community (specialist exercise clinic)	Any cancer type	What (materials) - Not reported Who (qualifications) - qualified yoga instructors How (delivery) – group-based in community When, how much (dosage) - 7 wk. program (1x75minute session). Combine initial breathing exercises, then 6–10 modified yoga poses, finish with relaxation exercise. Tailoring - Individualized as required
Marker	2018	Effectiveness	$n = 170$	Cost Feasibility	Intervention Patient	Community (specialist exercise clinic) + Home	Any cancer type	What (materials) - Not reported Who (qualifications) - Cancer Exercise Specialist or trained and supervised program interns completing a degree in Exercise Physiology or a related field How (delivery) - Commence with 2–3 individual session and then small group exercise When, how much (dosage) - Each session is 50 min in duration and commences with 10 min warm-up. Month one includes 2–3 individual sessions per wk., month two includes 2 group sessions (max 4 participants) per wk. and month three includes 1 group session per wk. Participants also receive unlimited access to the fitness facility during off-peak weekday hours and all day on weekends. Participants are provided with 3 levels of difficulty (easy, medium, hard). Home-based exercisers are given resources that includes pictures and descriptions of all exercises and complete a fitness log to track adherence. Exercise intensity during each session is highly adaptable and continuously adjusted Tailoring - Individualized and tailored plans
Muraca	2011	Implementation	$n = 51$	Acceptability	Patient	Hospital (out-patient) + Home	Breast cancer	What (materials) - Pedometer and resistance band Who (qualifications) - Fitness Professional (plus dietitian and social workers) How (delivery)- Group + Home-based When, how much (dosage) - 5x2hour sessions delivered over 10–12 wks. Includes a combination of diet, exercise and facilitated discussions to support behaviour change. A physical activity log is provided at the start of the program, DVD CD with 30 and 50 min

Table 3 Characteristics of included studies *(Continued)*

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
								audio coach-guided walking sessions. Recommendations include regular exercise initially 30 min 3–5 x/wk. Add resistance exercises Tailoring - Individualized and tailored plans
Noble	2012	Effectiveness	$n = 386$	Feasibility	Patient	Community (specialist exercise clinic)	Any cancer type	What (materials) - Polar heart rate monitor, resistance program integrates a range of equipment Who (qualifications) - Certified exercise physiologists How (delivery) - Group-based When, how much (dosage) - 2x/wk. for 1 h over 12 wks. Sessions include aerobic (progressively lengthened over 24 sessions and then increase intensity), resistance (15 reps increasing to 20 reps before weights are increased) and stretching/flexibility at the end of the session. No home exercise provided due to perceived risk. Tailoring - Individualized and modified as required based upon patient presentation.
Rajotte	2012	Effectiveness	$n = 221$	Acceptability Appropriateness	Patient Intervention	Community (fitness centre)	Any cancer type	What (materials) – Not reported Who (qualifications) - Personal trainer (ratio 1 trainer to 7 participants. Maximum 14 participants per group) How (delivery) - Group-based When, how much (dosage) - 2x/wk. for 12 wks (90-min sessions). 10-min aerobic warm-up, resistance exercise 50 min and 30 min 'community building' time. Participants and their immediate family receive a 12-wk YMCA membership. They can access the YMCA facilities on days other than the designated sessions and are encouraged to exercise outside the designated sessions. Tailoring - Individualized
Rogers	2019	Implementation	$n = 30$	Adoption Appropriateness Cost	Organisation Intervention Organisation	Community (specialist exercise clinic or fitness centre) + Home	Breast cancer	What (materials) – Not reported, however implementation toolkit is described that supports local adaptions based upon facilities Who (qualifications) - fitness instructor or physiotherapist How (delivery) – Combined group-based program with home exercises When, how much (dosage) - 12 supervised sessions (10 in month one and 2 in month two), home-based exercise beginning in week 3 to work towards 150 min/wk. of mod/vig physical activity by the end of the 3-month intervention, coupled with 3 physical activity counselling sessions (in-person or by telephone; one in month 2 and two in month 3), and 6 group discussions (three in month 1, two in month 2, and one in month

Table 3 Characteristics of included studies *(Continued)*

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
								3 Tailoring - Individualized
Santa Mina	2012	Implementation	NA	Adoption Cost	Organisation Organisation + Intervention	Community (specialist cancer clinic) + Home	Any cancer type	What (materials) - exercise bands, a stability ball, and a yoga mat Who (qualifications) - Multidisciplinary program (exercise component provided by certified exercise physiologist) How (delivery) - primarily a home-based program but participants can participate in group-based sessions if desired When, how much (dosage) - Home-based program, supported by adherence strategies (staff communicate (by telephone or e-mail) to address barriers, exercise manual that reinforces strategies for behaviour change, access to the weekly group exercise class to facilitate social support, access to educational seminar and psychologists to support behaviour change). Weekly group sessions are 90-min duration and include a 10-min warm-up, 20 min of low-impact aerobic exercise, 20 min of resistance training, and 10 min of cool-down Tailoring - Individualized
SantaMina	2017	Effectiveness	$n = 229$	Feasibility Fidelity	Patient Healthcare Provider	Community (specialist cancer clinic)	Any cancer type	What (materials) - Example - arm ergometers, treadmills, stationary cycles, mini-trampolines, and elliptical machines and resistance bands, free weights, stability balls, body bars Who (qualifications) - Physiotherapists, kinesiologists, or exercise physiologists who have completed an 8-h CancerSmart rehabilitation and exercise techniques course How (delivery) - Group-based, 2 leaders per 8–10 participant When, how much (dosage) - 30 wks exercise program (2x/wk. for 10 wks and then 1x/wk. for 20 wks). Each group session is 60 min in duration and includes aerobic interval training and resistance training, stretching, and balance exercises. Participants exercise at 50–80% of estimated heart rate range for 3–5 min and then move to musculoskeletal exercise. Cycle repeats 4–6 times with exercise recorded in patient logbook. Participants are encouraged to exercise independently, aiming to achieving 150 min of mod/vig physical activity per wk. Tailoring - Individualized programs
Santa Mina	2019	Effectiveness/ Implementation	$n = 207$	Acceptability Adoption Appropriateness	Patient Organisation Intervention	Home + Hospital (out-patient)	Any cancer type	What (materials) - exercise mat, resistance bands, a stability ball, and a detailed exercise program manual Who (qualifications) - Physiotherapist/ Occupational Therapist (comprehensive assessment), Kinesiologists (exercise

Table 3 Characteristics of included studies *(Continued)*

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
								programming) How (delivery)- individual with weekly group exercise class When, how much (dosage) – aerobic component included recommendation for 150 min of mod/vig intensity/week Resistance component included 2–3 sessions/wk. of 4–10 exercises Tailoring - Individualized programs
Sherman	2010	Effectiveness	*n* = 162	Acceptability Adoption Feasibility	Patient Organisation Patient	Community (fitness centre)	Breast cancer	What (materials) - heated swimming pool + separate room for floor-based exercise Who (qualifications) - Encore coordinator How (delivery)- Group-based When, how much (dosage) - 1 × 8 wk. (2-h session). Sessions included low-intensity mobility and stretching exercises (20 min), and progressive hydrotherapy resistance exercises (30 min) with 5-min warm-up and cool-down. Participants are given home exercise sheets that they are encouraged to complete daily. This is reviewed weekly by the Encore coordinator. Tailoring - Not reported
Speed-Andrews	2012	Effectiveness/ Implementation	*n* = 23	Feasibility	Patient	Community (specialist exercise clinic or fitness centre)	Breast cancer	What (materials) - blocks, bolsters, straps, blankets Who (qualifications) - licensed senior Iyengar yoga instructor and 2 assistants who are licensed instructors. How (delivery) - Group-based When, how much (dosage) - 6 (12 classes) or 12 (22 classes) wks, 90 min/session. Tailoring - postures were based on recommendations from Geeta Iyengar and adapted based on individual needs.
Swenson	2014	Effectiveness	*n* = 75	Appropriateness	Intervention	Community (specialist exercise clinic)	Any cancer type	What (materials) - treadmills, elliptical machines, upright and recumbent bikes, a Life-Fitness functional cable machine, and a walking track Who (qualifications) – Physiotherapist How (delivery) Individual assessment determined whether participants participated in individual or group sessions (maximum 4 participant) When, how much (dosage) - 8-wk program with option of 6 months maintenance. Combined aerobic exercise and strength training. Individual sessions 60 min duration. Group sessions 90 min Tailoring - Session intensity and duration were adjusted for participants according to individual physiological measures
VanGerpen	2013	Effectiveness/ Implementation	*n* = 121	Appropriateness	Intervention	Community (specialist exercise clinic)	Any cancer type	What (materials) - resistance band for home use. Stationary bike, treadmill, indoor walking

Table 3 Characteristics of included studies *(Continued)*

First Author	Year	Study type	Sample size	Implementation Outcome	Level of Analysis	Healthcare setting	Cancer diagnosis	Exercise intervention
								track, recumbent stepper, upper body ergometer. Dumbbell, machines, resistance band. Who (qualifications) - Physiotherapist or exercise physiologist How (delivery) - Group-based (max. 12 participants per group) When, how much (dosage) - 12-wk program. 30 min aerobic exercise (5-min intervals on equipment), 30 min of either strength (rotating through equipment described above), flexibly, Pilates, yoga, relaxation or water-based exercise. Patient monitored intensity Tailoring - Not reported
Wurz	2013	Implementation	NA	Adoption	Organisation	Community (specialist exercise clinic)	Any cancer type	What (materials) – Not reported Who (qualifications) - qualified yoga instructors How(delivery)- group-based in the community When, how much (dosage) - 7 wk. program (1x75minute session). Combine initial breathing exercises, then 6–10 modified yoga poses, finish with relaxation exercise. Tailoring - Individualized

Definition for settings
Community
Specialist exercise clinic - physical therapy clinics, specialist cancer centres or university-based publicly accessible specialist exercise centres
Fitness centre - recreation, sport or gymnasium settings
Hospital
Inpatient - exercise delivered for people admitted to hospital
Outpatient - exercise delivered for people not admitted to hospital
Home
Prescribed exercise program that is completed at home
Key:
NA not applicable; *Wk* week; *Mod* moderate; *Vig* vigorous; *ACSM* The American College of Sports Medicine; *APMHR* Age-predicted maximal heart rate; *MHR* Maximal heart rate; *HR* Heart rate; *HRR* Heart rate reserve; *RM* Repetition maximum; *RPE* Rate of perceived exertion

Table 4 Summary of characteristics of included studies

Descriptive Data (range)		
Sample size range	11–1635	
Intervention duration (months)	1–9	
Contact frequency (number of exercise sessions)	4–108	
Contact time (hours)[a]	8.75–108	
Follow-up (years)	NA - 2	
	Total studies (unique programs)	
	n	**%**
Study Design		
Quasi- experimental	16 (14)	43.2 (45.2)
Descriptive report	8 (6)	21.6 (19.4)
Observational	7 (6)	18.9 (19.4)
Randomised control trial	3 (2)	8.1 (6.5)
Mixed methods	2 (2)	5.4 (6.5)
Qualitative	1 (1)	2.7 (3.2)
Setting		
Community		
Fitness centre	11 (7)	29.7 (24.1)
Specialist exercise clinic	8 (8)	21.6 (27.6)
Combined specialist exercise clinic and fitness centre	3 (2)	8.1 (6.9)
Sub-total	*22 (17)*	*59.5 (58.6)*
Hybrid program		
Community + Home	9 (6)	24.3 (20.7)
Hospital + Home	2 (2)	5.4 (6.9)
Combined hospital + home + community	1 (1)	2.7 (3.4)
Hospital + Community	1 (1)	2.7 (3.4)
Sub-total	*13 (10)*	*35.1 (34.5)*
Hospital		
Not stated outpatient and/or inpatient	1 (1)	2.7 (3.4)
Outpatient	1 (1)	2.7 (3.4)
Inpatient	0 (0)	0.0 (0.0)
Sub-total	*2 (2)*	*5.4 (6.9)*
Home-program	0 (0)	0.0 (0.0)
Cancer Type		
Any cancer type	19 (16)	51.4 (55.2)
Breast Cancer	11 (8)	29.7 (27.6)
Prostate Cancer	5 (3)	13.5 (10.3)
Not specified	2 (2)	5.4 (6.9)
Intervention Type		
Mixed aerobic/resistance/stretching	32 (26)	86.5 (89.7)
Yoga	3 (2)	8.1 (6.9)
Football (soccer)	2 (1)	5.4 (3.4)
Intervention Delivery		
Group	20 (14)	54.1 (48.3)
Combination	14 (12)	37.8 (41.4)

Table 4 Summary of characteristics of included studies *(Continued)*

Descriptive Data (range)		
Not reported	2 (2)	5.4 (6.9)
Individual	1 (1)	2.7 (3.4)
Staff delivering the Intervention		
Qualified health professional (physiotherapy)	17 (14)	45.9 (48.3)
Fitness professional	10 (9)	27.0 (31.0)
Varied (qualified health professional + fitness professionals)	6 (4)	16.2 (13.8)
Not reported	4 (2)	10.8 (6.9)
Nurse/Medical professional	0 (0)	0.0 (0.0)

[a] based on studies that included time

implementation cost to be approximately $350 per participant [74]. Four studies reported that philanthropic donations were used to support the ongoing organisational costs associated with the exercise intervention [61, 63, 65, 75]. Hybrid models of funding subsided the costs associated with intervention use, including a mix of fee-for-service (upfront, set cost per session) and subsidised costs (total session costs off-set through donations, sponsorship) [48, 56, 60, 63, 65, 66, 72, 75]. Studies from the United States and Canada were the only ones to report on costs, where costs were measured as direct healthcare costs.

Feasibility

Twenty-one studies reported on the feasibility of delivering interventions, operationalised as either attendance and/or attrition rates for the exercise interventions [45–52, 54, 59, 62–67, 70–72, 77, 78], representing 17 unique programs. The attrition rates ranged from 22 to 56% across nine studies, with measurement of program discontinuation occurring between time ranges of 12 weeks to 6 months. The mean attrition rate for exercise intervention was 38.4% ($n = 7$) [46, 47, 50, 52, 59, 63, 64, 67, 77]. The attendance rates ranged from 30 to 83% across 16 studies. The mean attendance rate was calculated as 63.7% ($n = 15$) [45, 46, 48, 49, 51, 54, 62, 65–67, 70–72, 77, 78].

Fidelity

Six studies reported aspects of fidelity were monitored with reference to a documented pre-planned protocol for exercise and cancer [45–48, 54, 65]. Fidelity is typically measured by comparing the original protocol to what is delivered according to: 1) adherence to the protocol, 2) dose or amount of program (e.g., frequency, duration) delivered (with consideration of the core components that establish intervention effectiveness) and 3) quality of program delivery [82]. One study measured both adherence and quality of the program and stated adherence by football coaches to deliver the intervention as per the documented protocol was approximately 76%, and program quality was achieved through training staff [45]. A further five studies reported that the quality of program delivery was achieved through staff training and/or achieving certification to deliver their program as prescribed [46–48, 54, 65]. No studies were identified that monitored the amount of program delivery with respect to the pre-planned protocol.

Penetration

One study reported on exercise intervention penetration, which was defined as patients referred to the intervention reported with consideration to total eligible patient population [67]. This study, which evaluated the implementation of an exercise intervention for people diagnosed with breast cancer, reported that 53% of eligible patients were referred to the program [67].

Sustainability

One study reported on the sustainability of the exercise intervention within the organisational setting [64]. The authors also collected secondary outcome data about sustainability at the patient level, defined as whether the exercise sustained (> 12 months) the desired health outcomes for the patient [64]. Sustaining the program as part of normal organisational operations was attributed to addressing common challenges people diagnosed with cancer face in being active. This included providing tailored exercise by trained staff and establishing a not-for-profit entity to provide these services for free in the community [64]. The secondary outcome identified that the exercise intervention was effective in sustaining improvements to quality of life for patients [64].

Quality assessment

The quality of included studies explored through this review varied (refer to Supplementary Table 2). Studies were generally downgraded because they were not sufficiently powered to allow confidence in the inferences drawn about whole populations, and/or they failed to document possible differences between groups based on participants lost to follow-up. Further, many (64.5%, $n =$

Table 5 Synthesis of implementation outcomes and study classification across included studies

Study	*Implementation Outcomes*								*Study classification*		
First author & Year	***Acceptability***	***Adoption***	***Appropriateness***	***Cost***	***Feasibility***	***Fidelity***	***Penetration***	***Sustainability***	***Effectiveness***	***Implementation***	***Both***
Beidas 2014 [56]		X	X	X							X
Bjerre 2018 [45]			X	X	X	X			X		
Bjerre 2019 [57]			X						X		
Bultijnck 2018 [58]		X								X	
Brown 2019 [46]					X	X			X		
Cheifetz 2014 [47]					X	X					X
Cheifetz 2015 [59]					X						X
Culos-Reed 2018 [48]			X	X	X	X					X
Culos-Reed 2019 [60]				X						X	
Dalzell 2017 [61]		X		X						X	
Dennett 2017		X								X	
Dolan 2018 [62]			X		X				X		
Haas 2011 [63]		X		X	X					X	
Haas 2012 [64]					X			X	X		
Heston 2015 [65]		X		X	X	X				X	
Irwin 2017 [49]		X			X				X		
Kimmel 2014		X			X					X	
Kirkham 2016 [66]				X	X				X		
Kirkham 2018 [67]	X		X	X	X		X		X		
Kirkham 2019 [68]			X						X		
Leach 2014 [69]		X								X	
Leach 2015 [70]	X				X				X		
Leach 2016 [71]					X				X		
Mackenzie 2013 [51]			X		X				X		
Marker 2018 [72]				X	X				X		
Muraca 2011 [73]	X									X	
Noble 2012 [52]					X				X		
Rajotte 2012 [53]	X		X						X		
Rogers 2019 [74]		X	X	X						X	
Santa Mina 2012 [75]		X		X						X	
Santa Mina 2017 [54]					X	X			X		
Santa Mina 2019 [76]	X	X	X								X

Table 5 Synthesis of implementation outcomes and study classification across included studies *(Continued)*

Study	*Implementation Outcomes*								*Study classification*		
First author & Year	*Acceptability*	*Adoption*	*Appropriateness*	*Cost*	*Feasibility*	*Fidelity*	*Penetration*	*Sustainability*	*Effectiveness*	*Implementation*	*Both*
Sherman 2010 [77]	X	X			X				X		
Speed-Andrews 2012 [78]					X						X
Swenson 2014 [79]			X						X		
VanGerpen 2013 [80]			X								X
Wurz 2013 [55]		X								X	
TOTAL (*n* = 37)	**6 (16.2%)**	**14 (37.8%)**	**13 (35.1%)**	**12 (32.4%)**	**21 (56.8%)**	**6 (16.2%)**	**1 (2.7%)**	**1 (2.7%)**	**18 (48.6%)**	**12 (32.4%)**	**7 (18.9%)**
TOTAL (unique programs) (n = 31)	**6 (19.4%)**	**14 (45.2%)**	**11 (35.5%)**	**11 (35.5%)**	**17 (54.8%)**	**6 (19.4%)**	**1 (3.2%)**	**1 (3.2%)**	**15 (48.4%)**	**11 (35.5%)**	**6 (19.4%)**

6) of the studies classified as implementation studies were descriptive, with no objective measure of the implementation outcomes.

Discussion

This review identifies that exercise interventions are being implemented for people diagnosed with cancer using pragmatic study designs, but there is no consensus about how successful implementation should be defined, measured, and reported. Measuring implementation outcomes, using an established framework, can generate new knowledge in this area by conceptualising and defining what constitutes success [33]. To the best of our knowledge, this is the first systematic review that has explored implementation outcomes in exercise and cancer using the Implementation Outcomes Framework [30]. The included studies represent diverse interventions that are delivered across different settings and for various cancer types. For example, interventions involving yoga, sport, aerobic and resistance exercises were identified. These interventions were delivered in communities or hospitals and program eligibility (based on cancer diagnosis) varied across patient sub-type to include any cancer type through to being limited to a specific cancer type. Most studies adopted a quasi-experimental design applied to test effectiveness of the intervention, with descriptive designs more common in studies classified as implementation. The implementation outcomes that were most frequently assessed in the eligible studies were feasibility and adoption. Furthermore, the fidelity to intervention delivery is infrequently reported and the true cost of implementation is relatively unknown. Penetration and sustainability were the least frequently assessed implementation outcomes.

Almost 60% of included studies measured feasibility. Feasibility may have been measured more often than other implementation outcomes because of the interdependence with the clinical outcomes of exercise interventions (e.g., patients must adhere to the intervention to derive the desired clinical effect) and the ease of collection (e.g., staff can record attendance levels). It was also one of the few implementation outcomes that was explored at the patient-level by reporting patient attendance and/or attrition rates, recognising that factors at levels other than the patient can influence this outcome (e.g., resources provided by the organisation or expertise of the healthcare providers). Almost half the studies in this review were classified as effectiveness studies. Effectiveness studies typically focus on patient outcomes [83], conferring a focus on patient-level outcomes in included studies. Whilst outside the scope of this review, future studies should explore the feasibility of exercise interventions for other stakeholders such as those who assume non-clinical roles [84]. For example, this might apply to health administrators who fund exercise interventions and policy makers who establish the strategic policy environment in cancer care. Feasibility of exercise programs for program co-ordinators has been explored in the Canadian setting [84], however more research is needed. Successful implementation involves multiple stakeholders and whilst exercise services appear feasible for patients, it may not be feasible for funders or policy makers. This would also improve consistency with Proctor's definition of feasibility which suggests measurement at provider, organisation or setting level [30].

Some aspects of adoption were evaluated in the included studies, including the barriers and enablers that impact implementation and organisational uptake rates. Despite this, no studies were identified that measured overall adoption rates by healthcare providers. Measuring the proportion of healthcare providers that adopt the intervention could provide better insights into referral patterns through identifying who is making (and not making) referrals. Further, only the study by Rogers and colleagues [74] applied an implementation science framework to collate the adoption barriers and enablers. Implementation science frameworks can guide the comprehensive compilation of factors that influence implementation [32]. Subsequent research should build on the work of Rogers and colleagues to identify and test the effectiveness (and cost) of different strategies that can mitigate common implementation barriers. This may include the effectiveness of different implementation strategies that can facilitate systematic, routine referral by healthcare providers. A recently validated questionnaire completed by healthcare providers may assist in identifying relevant strategies specific to cancer and exercise [85].

Including a cost evaluation for these strategies would address another gap identified through this review. No studies were identified that measured the cost of implementation strategies. Providing this information would enable policymakers to make astute decisions about the sustainable funding of exercise interventions. Further, evidence suggests implementation strategies, such as staff training, can increase the likelihood of successful implementation [86, 87]. Implementation strategies are the actions undertaken designed to cause the change that produces the desired implementation outcome [88]. Conceptually, within implementation research they are the elements that sit between the intervention and the outcome and are the focus of empirical testing [89]. Most of the articles categorised as implementation in this review were descriptive and did not empirically test implementation strategies. Further, of the 37 included articles, only three were randomised control trials (representing 2 unique programs) and were described as effectiveness trials. Whilst the utility of randomised control trials for implementation research is contested [90], there is a need for implementation studies that use experimental designs to rigorously test strategies [91].

Another important finding established through this review was that fidelity is infrequently measured, with the quality of program delivery most frequently applied. Whilst accurately measuring fidelity is a challenge [82], it typically considers compliance with the intervention protocol and adaptions to this protocol (based on the setting, population). Compliance with the intervention protocol was difficult to establish. Most studies ($n = 25$, 80.6%) in this review were tailored which is recommended (at the individual level) to ensure exercise programs are suitable for participants [13]. What remains unclear is the extent and type of tailoring of intervention components and whether this extended to significant changes to the intervention which could be considered as 'adaptions' to the core elements of the program (consistent with Proctor's definition). Without this information it is difficult to accurately measure the fidelity of program delivery. More detailed reporting in future studies about how tailoring alters an intervention is needed and whether these changes extended to significant program adaptions and any impact on fidelity of delivery should be specified. For example, the review by Beidas and colleagues reported three changes to their program (training staff, adding a program co-ordinator and implementing a phone call reminder to increase uptake of the program) [56] which was part of a barrier and enabler analysis but is not related back to measuring an implementation outcome such as fidelity.

A major finding of this review relates to the later stages of implementation. Very few studies evaluated penetration and sustainability, indicating limited knowledge about how exercise interventions are continued after initial implementation efforts cease. Evidence suggests that many interventions are not sustained, or only parts of an intervention are sustained [40]. This can contribute to resource waste and delivery of ineffective interventions. More research is needed to investigate how interventions are integrated within organisational activities and sustained over time. This is particularly important given that sustaining interventions is a dynamic process that requires repeated and continued attention [92].

This review was guided by the Implementation Outcomes Framework. Other studies in exercise and cancer have used similar outcomes frameworks to explore the translation potential of exercise interventions based in the community [36], for specific cancer type (breast cancer) [93, 94] and to explore sustainability of interventions [95]. Like Jankowski and colleagues [95], our review confirmed a paucity of research that explores organisational-level factors that impact on sustainability of exercise interventions. However, our review does extend current knowledge beyond identifying adoption barriers and enablers [93] and organisation uptake rates [36] by exploring overall adoption rates of healthcare providers. Additionally, previous research has produced contrary results regarding reach and study participants representativeness of the broader population [93, 94]. The one study that measured penetration in this review found differences (in intervention reach) between those who were referred and those who were not referred to the intervention [67], suggesting a possible referral bias. Furthermore, despite the gaps in measuring and reporting implementation outcomes, effectiveness/implementation study protocols were identified through the screening process that plan to incorporate these outcomes [96–98]. This suggests researchers are recognising the value of measuring successful implementation using established outcome frameworks [30, 99]. This type of research will support the translation of research findings into practice, as proposed by the ACSM and other international health organisations.

This review is not without limitations. It was challenging to capture all relevant studies because of the inconsistencies in terminology. For example, in cancer care settings exercise may be included within a rehabilitation program, however we did not include rehabilitation as a search-term due to its generic nature. Several strategies were employed to overcome inconsistencies in terminology, including hand-searching the *Moving through Cancer* exercise program registry. A second limitation of this review was associated with delineating between efficacy and effectiveness studies. An existing categorisation was used to define studies [100], however some studies that were described by the authors as pragmatic employed methods synonymous with efficacy studies and were therefore excluded. Further, there is a lack of quality assessment tools that are designed specifically for implementation study designs. This resulted in some of the standard quality assessment items being not applicable to the eligible studies. Third, we excluded studies where people were specifically receiving end-of-life care, as distinct from long-term maintenance therapies. Finally, this review identified relatively few unique exercise interventions that were exclusive categorised as either effectiveness or implementation studies. In some cases, single programs were evaluated at multiple time points leading to multiple publications on the same program. As such, caution should be used when drawing conclusions from these findings.

The review results suggest exercise interventions may be successfully implemented, however relatively little information is published about how successful implementation is defined, measured and reported. This review examined all of Proctor et al. implementation outcomes. Future work should build on this review by investigating each implementation outcome in greater detail and across all levels of implementation (such as healthcare provider, organisation, and policy level). Currently, little data exist to: 1) quantify how many providers are adopting exercise interventions; 2) identify what portion of total eligible patient population are being referred to interventions; 3) define the total cost of implementation (including the cost of implementation strategies); and 4) understand how to sustain interventions over time. These outcomes become more valuable as we shift attention to those implementation strategies used in practice. Augmenting measures with qualitative data about how these outcomes were achieved is also required. This is particularly evident with feasibility, where outcomes varied despite high level of measurement. Further understanding how some interventions achieved higher levels of attendance/reduced attrition is required. The actions that lead to these outcomes should then be considered for replication in future implementation efforts. To conclude, measuring and evaluating implementation outcomes in cancer and exercise offers enormous potential to help conceptualise what is 'implementation success'. It paves the way to develop (and subsequently test) causal relationships between the exercise interventions, the strategies or tools used during implementation and the outcome achieved [101]. Only then will researchers in exercise and cancer begin to unpack the implementation process and explain 'how and why' implementation was successful.

Abbreviations
ACSM: American College of Sports Medicine; CERT: Consensus on Exercise Reporting Template; CPGs: Clinical practice guidelines; JBI: Joanna Briggs Institute; PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analysis

Supplementary Information
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Additional file 1: Supplementary Table 1. Search Strategy.

Additional file 2: Supplementary Table 2. Definitions of terms for study classification [102–104].

Additional file 3: Supplementary Table 3. Quality Assessment.

Additional file 4: Supplementary Table 4. Excluded Studies.

Additional file 5: Supplementary Table 5. Summary of results Implementation Outcomes.

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Authors' contributions
PC, SR, LC, NR, EZ and JR developed the review concept and design. LC and JR completed article screening with EZ. LC completed data analysis with review from EZ and NR. The first draft of the manuscript was written by LC. All authors commented on previous versions of the manuscript and provided critical review. All authors read and approved the final manuscript.

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Declarations

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Not applicable.

Consent for publication
Not applicable.

Competing interests
PC is the Founder and Director of EX-MED Cancer Ltd., a not-for-profit organisation that provides exercise medicine services to people with cancer. PC is the Director of Exercise Oncology EDU Pty Ltd., a company that provides fee for service training courses to upskill exercise professionals in delivering exercise to people with cancer.

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4.3 Concluding statements - Section 2 (chapters 3 and 4)

In Section 2 of this thesis, two novel evidence synthesis methods were applied that are theorised to be more valuable for informing implementation practice.

Meta-reviews, like the one conducted in Chapter 3, may support efforts to address the research-to-practice gap by answering a broader research question and providing a more accessible synthesis of the available evidence to support decision-making (1-3). The outcomes investigated through our meta-review (health benefits, safety and cost) can also support research uptake from systematic reviews (4, 5). As such, summarising these outcomes in one comprehensive review is likely valuable for producing evidence necessary for practice.

By contrast, efficacy trials were excluded in the systematic review included in Chapter 4, and we summarised implementation outcomes in real-world environments. Systematic reviews often strip out context (i.e., by summarising findings from randomised control trials that typically have a greater focus on internal validity), rendering them unhelpful for implementation (6, 7). By including study designs that are better able to capture context, the practical application of our findings may be enhanced. Further, the outcomes of interest for our review were guided by the IOF. Implementation outcomes can be applied in research studies as a measure of successful implementation. Synthesising these factors can help to identify information needed to facilitate the uptake and use of EBIs (8).

Through both reviews, several gaps (i.e., lack of reporting on safety and cost data in mental illness) and opportunities to advance the field (i.e., increase pragmatic evaluations of implementation outcomes in cancer care) were identified. Highlighting the gaps in the literature is important to ensure that future research builds on existing knowledge and avoids duplication and research waste. Highlighting gaps can also inform the development of clinically relevant research evidence (9-11). Without a shift in research methods, including evidence synthesis methods, it is unlikely that EBIs are being designed for implementation practice. By extension, we also need a greater understanding of how to support successful implementation. Notably, while evidence is of foundational importance to implementation science (12), the methods employed here should not be considered a *silver bullet*. They are valuable adaptions to elicit information more helpful for implementation practice and translational efforts, with implementation research also needed to augment the existing evidence base.

In the next section of this thesis, two studies (described across three chapters) are conducted that explore the implementation of exercise EBIs in mental health and cancer care settings. The studies are implementation research trials that build on the existing evidence base for exercise EBIs by focusing on how implementation occurs. The studies also adopt innovative methods that are replicated across multiple sites to develop generalisable knowledge that can support future implementation efforts.

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5.0 CHAPTER FIVE: Developing an implementation research logic model: using a multiple case study design to establish a worked exemplar

5.1 Preamble

Section 2 of this thesis addressed the first sub-aim of this thesis by demonstrating how novel evidence synthesis methods can support the improved production of research useful for implementing exercise EBIs in mental health and cancer care. Section 3 (chapters 5, 6 and 7) addresses the second sub-aim of this thesis:

- *Explore how healthcare organisations have successfully implemented exercise EBIs within the routine practice for treating mental illness and cancer.*

This chapter provides an overview of the methodology that is subsequently applied in chapters 6 and 7 to understand how exercise EBIs have been successfully implemented in healthcare settings for the treatment of mental illness and cancer. We introduce the innovative methods applied to link multiple implementation science frameworks that combined, help explain the whole implementation process, including determinants, implementation strategies and implementation outcomes. The explanation of the implementation process is brought together through the IRLM and by using a multiple case study design.

The work presented through Chapter 5 has been published:

5.2 Published manuscript

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Developing an implementation research logic model: using a multiple case study design to establish a worked exemplar

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Abstract

Background: Implementation science frameworks explore, interpret, and evaluate different components of the implementation process. By using a program logic approach, implementation frameworks with different purposes can be combined to detail complex interactions. The Implementation Research Logic Model (IRLM) facilitates the development of causal pathways and mechanisms that enable implementation. Critical elements of the IRLM vary across different study designs, and its applicability to synthesizing findings across settings is also under-explored. The dual purpose of this study is to develop an IRLM from an implementation research study that used case study methodology and to demonstrate the utility of the IRLM to synthesize findings across case sites.

Method: The method used in the exemplar project and the alignment of the IRLM to case study methodology are described. Cases were purposely selected using replication logic and represent organizations that have embedded exercise in routine care for people with cancer or mental illness. Four data sources were selected: semi-structured interviews with purposely selected staff, organizational document review, observations, and a survey using the Program Sustainability Assessment Tool (PSAT). Framework analysis was used, and an IRLM was produced at each case site. Similar elements within the individual IRLM were identified, extracted, and re-produced to synthesize findings across sites and represent the generalized, cross-case findings.

Results: The IRLM was embedded within multiple stages of the study, including data collection, analysis, and reporting transparency. Between 33-44 determinants and 36-44 implementation strategies were identified at sites that informed individual IRLMs. An example of generalized findings describing "intervention adaptability" demonstrated similarities in determinant detail and mechanisms of implementation strategies across sites. However, different strategies were applied to address similar determinants. Dependent and bi-directional relationships operated along the causal pathway that influenced implementation outcomes.

Conclusions: Case study methods help address implementation research priorities, including developing causal pathways and mechanisms. Embedding the IRLM within the case study approach provided structure and added to the transparency and replicability of the study. Identifying the similar elements across sites helped synthesize findings and give a general explanation of the implementation process. Detailing the methods provides an example for replication that can build generalizable knowledge in implementation research.

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Keywords: Logic model, Case study methods, Causal pathways, Causal mechanisms

Contributions to the literature

- Logic models can help understand how and why evidence-based interventions (EBIs) work to produce intended outcomes.
- The implementation research logic model (IRLM) provides a method to understand causal pathways, including determinants, implementation strategies, mechanisms, and implementation outcomes.
- We describe an exemplar project using a multiple case study design that embeds the IRLM at multiple stages. The exemplar explains how the IRLM helped synthesize findings across sites by identifying the common elements within the causal pathway.
- By detailing the exemplar methods, we offer insights into how this approach of using the IRLM is generalizable and can be replicated in other studies.

Background

The practice of implementation aims to get "someone..., somewhere... to do something differently" [1]. Typically, this involves changing individual behaviors and organizational processes to improve the use of evidence-based interventions (EBIs). To understand this change, implementation science applies different theories, models, and frameworks (hereafter "frameworks") to describe and evaluate the factors and steps in the implementation process [2–5]. Implementation science provides much-needed theoretical frameworks and a structured approach to process evaluations. One or more frameworks are often used within a program of work to investigate the different stages and elements of implementation [6]. Researchers have acknowledged that the dynamic implementation process could benefit from using logic models [7]. Logic models offer a systematic approach to combining multiple frameworks and to building causal pathways that explain the mechanisms behind individual and organizational change.

Logic models visually represent how an EBI is intended to work [8]. They link the available resources with the activities undertaken, the immediate outputs of this work, and the intermediate outcomes and longer-term impacts [8, 9]. Through this process, causal pathways are identified. For implementation research, the causal pathway provides the interconnection between a chosen EBI, determinants, implementation strategies, and implementation outcomes [10]. Testing causal mechanisms in the research translation pathway will likely dominate the next wave of implementation research [11, 12]. Causal mechanisms (or mechanisms of change) are the "process or event through which an implementation strategy operates to affect desired implementation outcomes" [13]. Identifying mechanisms can improve implementation strategies' selection, prioritization, and targeting [12, 13]. This provides an efficient and evidence-informed approach to implementation.

Implementation researchers have proposed several methods to develop and examine causal pathways [14, 15] and mechanisms [16, 17]. This includes formalizing the inherent relationship between frameworks via developing the Implementation Research Logic Model (IRLM) [7]. The IRLM is a logic model designed to improve the rigor and reproducibility of implementation research. It specifies the relationship between elements of implementation (determinant, strategies, and outcomes) and the mechanisms of change. To do this, it recommends linking implementation frameworks or relevant taxonomies (e.g., determinant and evaluation frameworks and implementation strategy taxonomy). The IRLM authors suggest the tool has multiple uses, including planning, executing, and reporting on the implementation process and synthesizing implementation findings across different contexts [7]. During its development, the IRLM was tested to confirm its utility in planning, executing, and reporting; however, its utility in synthesizing findings across different contexts is ongoing. Users of the tool are encouraged to consider three principles: (1) comprehensiveness in reporting determinants, implementation strategies, and implementation outcomes; (2) specifying the conceptual relationships via diagrammatic tools such as colors and arrows; and (3) detailing important elements of the study design. Further, the authors also recognize that critical elements of IRLM will vary across different study designs.

This study describes the development of an IRLM from a multiple case study design. Case study methodology can answer "how and why" questions about implementation. They enable researchers to develop a rich, in-depth understanding of a contemporary phenomenon within its natural context [18–21]. These methods can create coherence in the dynamic context in which EBIs exist [22, 23]. Case studies are common in implementation research [24–30], with multiple case study designs suitable for undertaking comparisons across contexts [31, 32]. However, they are infrequently applied to establish mechanisms [11] or combine implementation elements to synthesize findings across contexts (as possible through the IRLM). Hollick and colleagues [33] undertook a comparative case study, guided by a determinant framework, to explore how context influences successful implementation. The authors contrasted determinants across sites where implementation was successful versus sites where implementation failed. The study did not extend to identifying implementation strategies or mechanisms. By contrast, van Zelm et al. [31] undertook a theory-driven evaluation of successful implementation across ten hospitals. They used joint displays to present mechanisms of change aligned with evaluation outcomes; however, they did not identify the implementation strategies within the causal pathway. Our study seeks to build on these works and explore the utility of the IRLM in synthesizing findings across sites. The dual objectives of this paper were to:

- Describe how case study methods can be applied to develop an IRLM
- Demonstrate the utility of the IRLM in synthesizing implementation findings across case sites.

Method

In this section, we describe the methods used in the exemplar case study and the alignment of the IRLM to this approach. The exemplar study explored the implementation of exercise EBIs in the context of the Australian healthcare system. The exemplar study aimed to investigate the integration of exercise EBIs within routine mental illness or cancer care. The evidence base detailing the therapeutic benefits of exercise for non-communicable diseases such as cancer and mental illness are extensively documented [34–36] but inconsistently implemented as part of routine care [37–44].

Additional file 1 provides the Standards for Reporting Qualitative Research (SRQR).

Case study approach

We adopted an approach to case studies based on the methods described by Yin [18]. This approach is said to have post-positivist philosophical leanings, which are typically associated with the quantitative paradigm [19, 45, 46]. This is evidenced by the structured, deductive approach to the methods that are described with a constant lens on objectivity, validity, and generalization [46]. Yin's approach to case studies aligns with the IRLM for several reasons. The IRLM is designed to use established implementation frameworks. The two frameworks and one taxonomy applied in our exemplar were the Consolidated Framework for Implementation Research (CFIR) [47], Expert Recommendations for Implementing Change (ERIC) [48], and Proctor et al.'s implementation outcomes framework [49]. These frameworks guided multiple aspects of our study (see Table 1). Commencing an implementation study with a preconceived plan based upon established frameworks is deductive [22]. Second, the IRLM has its foundation in logic modeling to develop cause and effect relationships [8]. Yin advocates using logic models to analyze case study findings [18]. They argue that developing logic models encourages researchers to iterate and consider plausible counterfactual explanations before upholding the causal pathway. Further, Yin notes that case studies are particularly valuable for explaining the transitions and context within the cause-and-effect relationship [18]. In our exemplar, the transition was the mechanism between the implementation strategy and implementation outcome. Finally, the proposed function of IRLM to synthesize findings across sites aligns with the exemplar study that used a multiple case approach. Multiple case studies aim to develop generalizable knowledge [18, 50].

Case study selection and boundaries

A unique feature of Yin's approach to multiple case studies is using replication logic to select cases [18]. Cases are chosen to demonstrate similarities (literal replication) or differences for anticipated reasons (theoretical replication) [18]. In the exemplar study, the cases were purposely selected using literal replication and displayed several common characteristics. First, all cases had delivered exercise EBIs within normal operations for at least 12 months. Second, each case site delivered exercise EBIs as part of routine care for a non-communicable disease (cancer or mental illness diagnosis). Finally, each site delivered the exercise EBI within the existing governance structures of the Australian healthcare system. That is, the organizations used established funding and service delivery models of the Australian healthcare system.

Using replication logic, we posited that sites would exhibit some similarities in the implementation process across contexts (literal replication). However, based on existing implementation literature [32, 51–53], we expected sites to adapt the EBIs through the implementation process. The determinant analysis should explain these adaptions, which is informed by the CFIR (theoretical replication). Finally, in case study methods, clearly defining the boundaries of each case and the units of analysis, such as individual, the organization or intervention, helps focus the research. We considered each healthcare organization as a separate case. Within that,

Table 1 Theoretical application within the study and operational definitions/measures for implementation outcomes

Framework	Application to research study		
Consolidated Framework for Implementation Research (CFIR)	The CFIR is applied in this study to identify and describe the determinants that influenced implementation at each site. The semi-structured interview guide was developed with reference to the *CFIR interview building tool*. During data analysis, each CFIR construct was established as a code and as examples were identified, they were indexed to the relevant determinant.		
Expert Recommendations for Implementing Change (ERIC)	The ERIC taxonomy is applied in the study to develop consistent descriptions of the actions undertaken at each case site used to facilitate implementation. The *ERIC—discrete implementation strategy compilation with ancillary material (Additional file 6)*—provided a reference tool that aided data collection and interpretation of data sources. During data analysis, each ERIC strategy was applied as a code. As examples were identified, they were indexed to the relevant ERIC strategy.		
Implementation outcomes framework	The Implementation Outcomes Framework defines 8 implementation outcomes, of which this study focused on 4: acceptability, fidelity, penetration, and sustainability. Each implementation outcome was operationalized and a measure defined which guided data collection (see below). During data analysis each implementation outcome was established as a code and as examples were identified, they were indexed to the relevant implementation outcome.		
	Operational definition for implementation outcome	**Measure**	
Acceptability	How is exercise EBI perceived in the organization?	Direct question	
Fidelity	Comparison of exercise EBI protocol with what is delivered as measured by dose/amount and quality of program delivery	*Dose/amount* *Quality*	Sessions/duration per week Total program delivered versus intended amount (dose delivered) Attendance rates (dose received) Evidence of training to support delivery
Penetration	Measured at the service level (reach) and at the organizational system level (policies/procedures that evidence the EBI)	*Reach* *System level penetration*	Number of people who use the service versus total population Evidence of job descriptions, budget, and strategic plans that reference the exercise EBI
Sustainability	Evidence of continued health benefit, program components and evolution overtime	*Health benefits* *Program components* *Evolution*	Process exits to measure health benefits in patients Survey (PSAT) Survey (PSAT)

EBI evidence-based intervention, *PSAT* Program Sustainability Assessment Tool, *CFIR* Consolidated Framework for Implementation Research, *ERIC* Expert Recommendations for Implementing Change organizational-level analysis [18, 54] and operationalizing the implementation outcomes focused inquiry (Table 1).

Data collection

During the study conceptualization for the exemplar, we mapped the data sources to the different elements of the IRLM (Fig. 1). Four primary data sources informed data collection: (1) semi-structured interviews with staff; (2) document review (such as meeting minutes, strategic plans, and consultant reports); (3) naturalistic observations; and (4) a validated survey (Program Sustainability Assessment Tool (PSAT)). A case study database was developed using Microsoft Excel to manage and organize data collection [18, 54].

Semi-structured interviews

An interview guide was developed, informed by the CFIR interview guide tool [55]. Questions were selected across the five domains of the CFIR, which aligned with the delineation of determinant domains in the IRLM. Purposeful selection was used to identify staff for the interviews [56]. Adequate sample size in qualitative studies, particularly regarding the number of interviews, is often determined when data saturation is reached [57, 58]. Unfortunately, there is little consensus on the definition of saturation [59], how to interpret when it has occurred [57], or whether it is possible to pre-determine in qualitative studies [60]. The number of participants in this study was determined based on the staff's differential experience with the exercise EBI and their role in the organization. This approach sought to obtain a rounded view of how the EBI operated at each site [23, 61]. Focusing on staff experiences also aligned with the organizational lens that bounded the study. Typical roles identified for the semi-structured interviews included the health professional delivering the EBI, the program manager responsible for the EBI, an organizational executive, referral sources, and other health professionals (e.g., nurses, allied health). Between five and ten interviews were conducted at each site. Interview times ranged from 16 to 72 min, most lasting around 40 min per participant.

Document review

A checklist informed by case study literature was developed outlining the typical documents the research team was seeking [18]. The types of documents sought to review included job descriptions, strategic plans/planning documents, operating procedures and organizational policies, communications (e.g., website, media releases, email, meeting minutes), annual reports, administrative databases/files, evaluation reports, third party consultant reports, and routinely collected numerical data that measured implementation outcomes [27]. As each document was identified, it was numbered, dated,

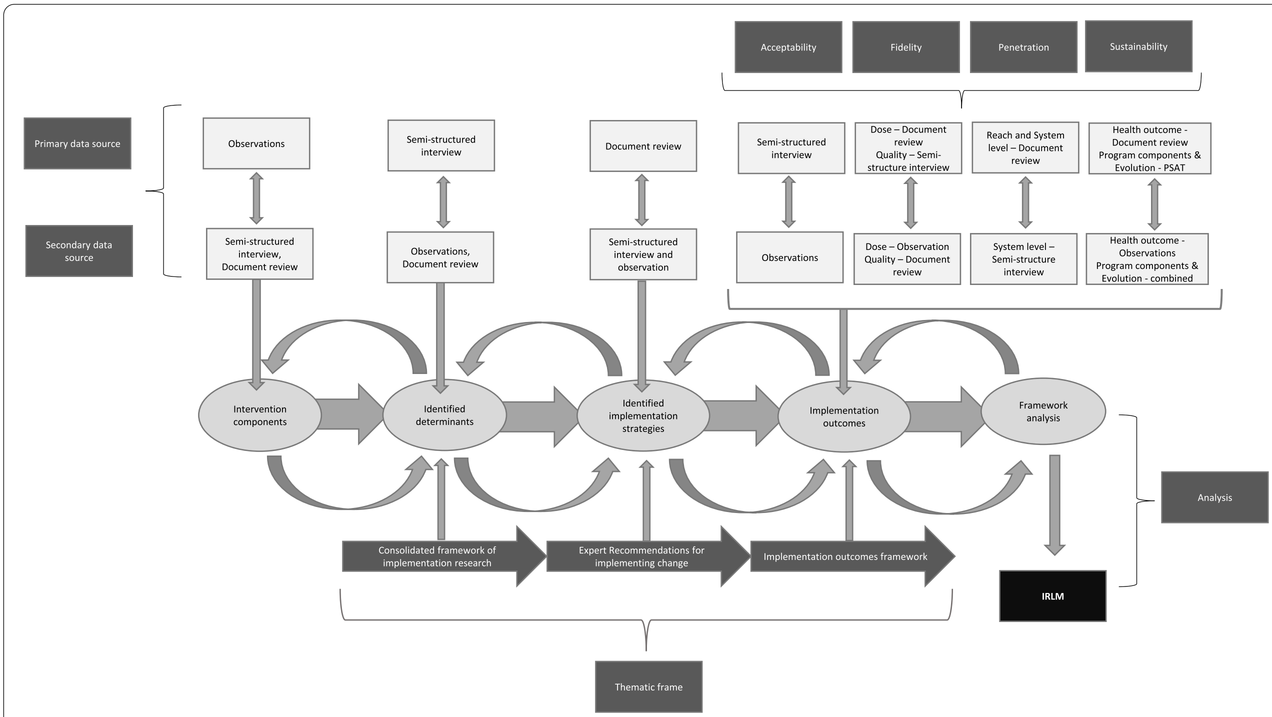

Fig. 1 Conceptual frame for the study

and recorded in the case study database with a short description of the content related to the research aims and the corresponding IRLM construct. Between 24 and 33 documents were accessed at each site. A total of 116 documents were reviewed across the case sites.

Naturalistic observations

The onsite observations occurred over 1 week, wherein typical organizational operations were viewed. The research team interacted with staff, asked questions, and sought clarification of what was being observed; however, they did not disrupt the usual work routines. Observations allowed us to understand how the exercise EBI operated and contrast that with documented processes and procedures. They also provided the opportunity to observe non-verbal cues and interactions between staff. While onsite, case notes were recorded directly into the case study database [62, 63]. Between 15 and 40 h were spent on observations per site. A total of 95 h was spent across sites on direct observations.

Program sustainability assessment tool (survey)

The PSAT is a planning and evaluation tool that assesses the sustainability of an intervention across eight domains [64–66]: (1) environmental support, (2) funding stability, (3) partnerships, (4) organizational capacity, (5) program evaluation, (6) program adaption, (7) communication, and (8) strategic planning [64, 65]. The PSAT was administered to a subset of at least three participants per site who completed the semi-structured interview. The results were then pooled to provide an organization-wide view of EBI sustainability. Three participants per case site are consistent with previous studies that have used the tool [67, 68] and recommendations for appropriate use [65, 69].

We included a validated measure of sustainability, recognizing calls to improve understanding of this aspect of implementation [70–72]. Noting the limited number of measurement tools for evaluating sustainability [73], the PSAT's characteristics displayed the best alignment with the study aims. To determine "best alignment," we deferred to a study by Lennox and colleagues that helps researchers select suitable measurement tools based on the conceptualization of sustainability in the study [71]. The PSAT provides a multi-level view of sustainability. It is a measurement tool that can be triangulated with other implementation frameworks, such as the CFIR [74], to interrogate better and understand the later stages of implementation. Further, the tool provides a contemporary account of an EBIs capacity for sustainability [75]. This is consistent with case study methods, which explore complex, contemporary, real-life phenomena.

The voluminous data collection that is possible through case studies, and is often viewed as a challenge of the method [19], was advantageous to developing the IRLM in the exemplar and identifying the causal pathways. First, it aided three types of triangulation through the study (method, theory, and data source triangulation) [76]. Method triangulation involved collecting evidence via four methods: interview, observations, document review, and survey. Theoretical triangulation involved applying two frameworks and one taxonomy to understand and interpret the findings. Data source triangulation involved selecting participants with different roles within the organization to gain multiple perspectives about the phenomena being studied. Second, data collection facilitated depth and nuance in detailing determinants and implementation strategies. For the determinant analysis, this illuminated the subtleties within context and improved confidence and accuracy for prioritizing determinants. As case studies are essentially "naturalistic" studies, they provide insight into strategies that are implementable in pragmatic settings. Finally, the design's flexibility enabled the integration of a survey and routinely collected numerical data as evaluation measures for implementation outcomes. This allowed us to contrast "numbers" against participants' subjective experience of implementation [77].

Data analysis

Descriptive statistics were calculated for the PSAT and combined with the three other data sources wherein framework analysis [78, 79] was used to analyze the data. Framework analysis includes five main phases: familiarization, identifying a thematic framework, indexing, charting, and mapping and interpretation [78]. *Familiarization* occurred concurrently with data collection, and the *thematic frame* was aligned to the two frameworks and one taxonomy we applied to the IRLM. To *index and chart* the data, the raw data was uploaded into NVivo 12 [80]. Codes were established to guide indexing that aligned with the thematic frame. That is, determinants within the CFIR [47], implementation strategies listed in ERIC [48], and the implementation outcomes [49] of acceptability, fidelity, penetration, and sustainability were used as codes in NVivo 12. This process produced a framework matrix that summarized the information housed under each code at each case site.

The final step of framework analysis involves *mapping and interpreting* the data. We used the IRLM to map and interpret the data in the exemplar. First, we identified the core elements of the implemented exercise EBI. Next, we applied the CFIR valance and strength coding to prioritize the contextual determinants. Then, we identified the implementation strategies used to address the contextual determinants. Finally, we provided a rationale (a causal mechanism) for how these strategies worked to address barriers and contribute to specific implementation outcomes. The systematic approach advocated by the IRLM provided a transparent representation of the causal pathway underpinning the implementation of the exercise EBIs. This process was followed at each case site to produce an IRLM for each organization. To compare, contrast, and synthesize findings across sites, we identified the similarities and differences in the individual IRLMs and then developed an IRLM that explained a generalized process for implementation. Through the development of the causal pathway and mechanisms, we deferred to existing literature seeking to establish these relationships [81–83]. Aligned with case study methods, this facilitated an iterative process of constant comparison and challenging the proposed causal relationships. Smith and colleagues advise that the IRLM "might be viewed as a somewhat simplified format," and users are encouraged to "iterate on the design of the IRLM to increase its utility" [7]. Thus, we re-designed the IRLM within a traditional logic model structure to help make sense of the data collected through the case studies. Figure 1 depicts the conceptual frame for the study and provides a graphical representation of how the IRLM pathway was produced.

Results

The results are presented with reference to the three principles of the IRLM: *comprehensiveness, indicating the key conceptual relationship* and *specifying critical study design*. The case study method allowed for comprehensiveness through the data collection and analysis described above. The mean number of data sources informing the analysis and development of the causal pathway at each case site was 63.75 (interviews ($M = 7$), observational hours (M=23.75), PSAT (M=4), and document review ($M = 29$). This resulted in more than 30 determinants and a similar number of implementation strategies identified at each site (determinant range per site = 33–44; implementation strategy range per site = 36–44). Developing a framework matrix meant that each determinant (prioritized and other), implementation strategy, and implementation outcome were captured. The matrix provided a direct link to the data sources that informed the content within each construct. An example from each construct was collated alongside the summary to evidence the findings.

The *key conceptual relationship* was articulated in a traditional linear process by aligning determinant → implementation strategy → mechanism → implementation outcome, as per the IRLM. To synthesize findings across sites, we compared and contrasted the results within each of the individual IRLM and extracted similar elements to develop a generalized IRLM that represents cross-case findings. By redeveloping the IRLM within a traditional logic model structure, we added visual representations of the bi-directional and dependent relationships, illuminating the dynamism within the implementation process. To illustrate, intervention adaptability was a prioritized determinant and enabler across sites. Healthcare providers recognized that adapting and tailoring exercise EBIs increased "fit" with consumer needs. This also extended to adapting how healthcare providers referred consumers to exercise so that it was easy in the context of their other work priorities. Successful adaption was contingent upon a qualified workforce with the required skills and competencies to enact change. Different implementation strategies were used to make adaptions across sites, such as promoting adaptability and using data experts. However, despite the different strategies, successful adaptation created positive bi-directional relationships. That is, healthcare providers' confidence and trust in the EBI grew as consumer engagement increased and clinical improvements were observed. This triggered greater engagement with the EBI (e.g., acceptability → penetration → sustainability), albeit the degree of engagement differed across sites. Figure 2 illustrates this relationship within the IRLM and provides a contrasting relationship by highlighting how a prioritized barrier across sites (available resources) was addressed.

The final principle is to *specify critical study design*, wherein we have described how case study methodology was used to develop the IRLM exemplar. Our intention was to produce an explanatory causal pathway for the implementation process. The implementation outcomes of acceptability and fidelity were measured at the level of the provider, and penetration and sustainability were measured at the organizational level [49]. Service level and clinical level outcomes were not identified for a priori measurement throughout the study. We did identify evidence of clinical outcomes that supported our overall findings via the document review. Historical evaluations on the service indicated patients increased their exercise level or demonstrated a change in symptomology/function. The implementation strategies specified in the study were those chosen by the organizations. We did not attempt to augment routine practice or change implementation outcomes by introducing new strategies. The barriers across sites were represented with a (B) symbol and enablers with an (E) symbol in the IRLM. In the individual IRLM, consistent determinants and strategies were highlighted (via bolding) to support extraction. Finally, within the generalized IRLM, the implementation strategies are grouped according to the ERIC taxonomy

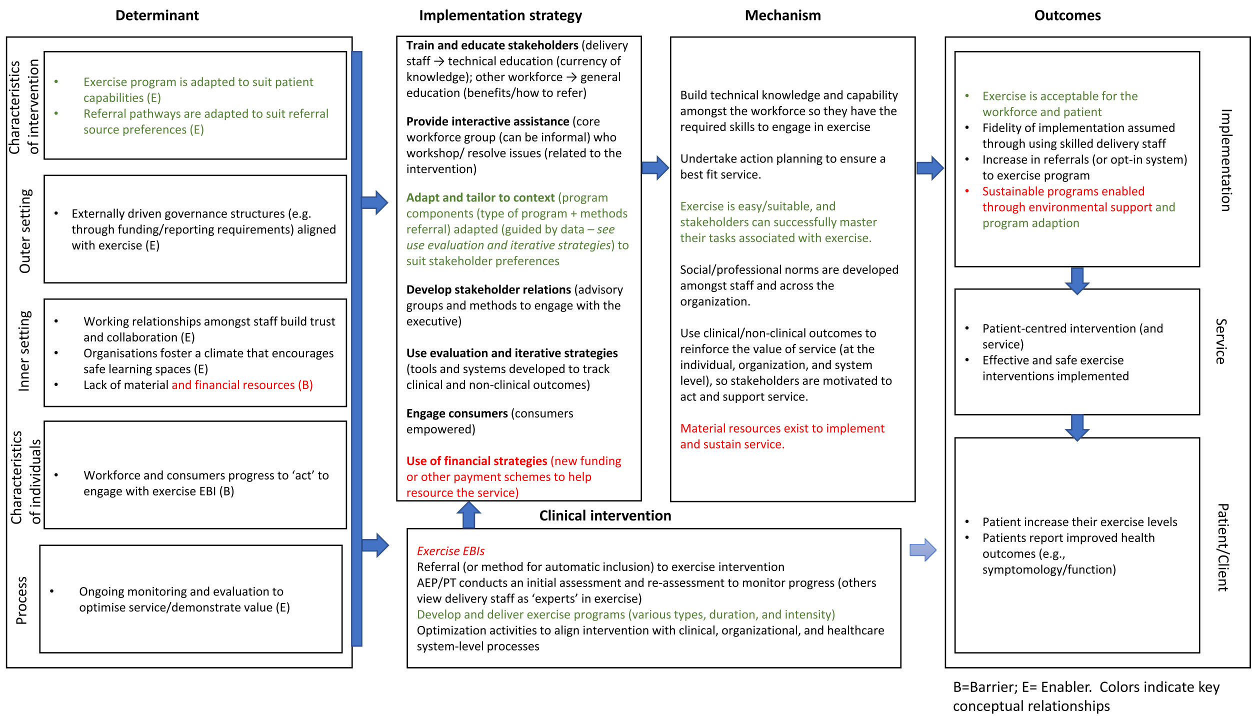

Fig. 2 Example of intervention adaptability (E) contrasted with available resources (B) within a synthesised IRLM across case sites

category. This accounts for the different strategies applied to achieve similar outcomes across case studies.

Discussion

This study provides a comprehensive overview that uses case study methodology to develop an IRLM in an implementation research project. Using an exemplar that examines implementation in different healthcare settings, we illustrate how the IRLM (that documents the causal pathways and mechanisms) was developed and enabled the synthesis of findings across sites.

Case study methodologies are fraught with inconsistencies in terminology and approach. We adopted the method described by Yin. Its guiding paradigm, which is rooted in objectivity, means it can be viewed as less flexible than other approaches [46, 84]. We found the approach offered sufficient flexibility within the frame of a defined process. We argue that the defined process adds to the rigor and reproducibility of the study, which is consistent with the principles of implementation science. That is, accessing multiple sources of evidence, applying replication logic to select cases, maintaining a case study database, and developing logic models to establish causal pathways, demonstrates the reliability and validity of the study. The method was flexible enough to embed the IRLM within multiple phases of the study design, including conceptualization, philosophical alignment, and analysis. Paparini and colleagues [85] are developing guidance that recognizes the challenges and unmet value of case study methods for implementation research. This work, supported by the UK Medical Research Council, aims to enhance the conceptualization, application, analysis, and reporting of case studies. This should encourage and support researchers to use case study methods in implementation research with increased confidence.

The IRLM produced a relatively linear depiction of the relationship between context, strategies, and outcomes in our exemplar. However, as noted by the authors of the IRLM, the implementation process is rarely linear. If the tool is applied too rigidly, it may inadvertently depict an overly simplistic view of a complex process. To address this, we redeveloped the IRLM within a traditional logic model structure, adding visual representations of the dependent and bidirectional relationships evident within the general IRLM pathway [86]. Further, developing a general IRLM of cross-case findings that synthesized results involved a more inductive approach to identifying and extracting similar elements. It required the research team to consider broader patterns in the data before offering a prospective account of the implementation process. This was in contrast to the earlier analysis phases that directly mapped determinants and strategies to the CFIR and ERIC taxonomy. We argue that extracting similar elements is analogous to approaches that have variously been described as portable elements [87], common elements [88], or generalization by mechanism [89]. While defined and approached slightly differently, these approaches aim to identify elements frequently shared across effective EBIs and thus can form the basis of future EBIs to increase their utility, efficiency, and effectiveness [88]. We identified similarities related to determinant detail and mechanism of different implementation strategies across sites. This finding supports the view that many implementation strategies could be suitable, and selecting the "right mix" is challenging [16]. Identifying common mechanisms, such as increased motivation, skill acquisition, or optimizing workflow, enabled elucidation of the important functions of strategies. This can help inform the selection of appropriate strategies in future implementation efforts.

Finally, by developing individual IRLMs and then re-producing a general IRLM, we synthesized findings across sites and offered generalized findings. The ability to generalize from case studies is debated [89, 90], with some considering the concept a fallacy [91]. That is, the purpose of qualitative research is to develop a richness through data that is situated within a unique context. Trying to extrapolate from findings is at odds with exploring unique context. We suggest the method described herein and the application of IRLM could be best applied to a form of generalization called 'transferability' [91, 92]. This suggests that findings from one study can be transferred to another setting or population group. In this approach, the new site takes the information supplied and determines those aspects that would fit with their unique environment. We argue that elucidating the implementation process across multiple sites improves the confidence with which certain "elements" could be applied to future implementation efforts. For example, our approach may also be helpful for multi-site implementation studies that use methods other than case studies. Developing a general IRLM through study conceptualization could identify consistencies in baseline implementation status across sites. Multi-site implementation projects may seek to introduce and empirically test implementation strategies, such as via a cluster randomized controlled trial [93]. Within this study design, baseline comparison between control and intervention sites might extend to a comparison of organizational type, location and size, and individual characteristics, but not the chosen implementation strategies [94]. Applying the approach described within our study could enhance our understanding of how to support effective implementation.

Limitations
After the research team conceived this study, the authors of the PSAT validated another tool for use in clinical settings (Clinical Sustainability Assessment Tool (CSAT)) [95]. This tool appears to align better with our study design due to its explicit focus on maintaining structured clinical care practices. The use of multiple data sources and consistency in some elements across the PSAT and CSAT should minimize the limitations in using the PSAT survey tool. At most case sites, limited staff were involved in developing and implementing exercise EBI. Participants who self-selected for interviews may be more invested in assuring positive outcomes for the exercise EBI. Inviting participants from various roles was intended to reduce selection bias. Finally, we recognize recent correspondence suggesting the IRLM misses a critical step in the causal pathway. That is the mechanism between determinant and selection of an appropriate implementation strategy [96]. Similarly, Lewis and colleagues note that additional elements, including pre-conditions, moderators, and mediators (distal and proximal), exist within the causal pathway [13]. Through the iterative process of developing the IRLM, decisions were made about the determinant → implementation strategy relationship; however, this is not captured in the IRLM. Secondary analysis of the case study data would allow elucidation of these relationships, as this information can be extracted through the case study database. This was outside the scope of the exemplar study.

Conclusion
Developing an IRLM via case study methods proved useful in identifying causal pathways and mechanisms. The IRLM can complement and enhance the study design by providing a consistent and structured approach. In detailing our approach, we offer an example of how multiple case study designs that embed the IRLM can aid the synthesis of findings across sites. It also provides a method that can be replicated in future studies. Such transparency adds to the quality, reliability, and validity of implementation research.

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s43058-022-00337-8.

Additional file 1. Standards for Reporting Qualitative Research (SRQR).

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Authors' contributions
LC, EZ, SR, JR, PC, and NR contributed to the conceptualization of the study. LC undertook the data collection, and LC, EZ, SR, JR, PC, and NR supported the analysis. The first draft of the manuscript was written by LC with NR and EZ providing first review. LC, EZ, SR, JR, PC, and NR commented on previous versions of the manuscript and provided critical review. All authors read and approved the final manuscript.

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Availability of data and materials
The data that support the findings of this study are available on request from the corresponding author [LC]. The data are not publicly available due to them containing information that could compromise research participant privacy.

Declarations

Ethics approval and consent to participate
This study is approved by Sydney Local Health District Human Research Ethics Committee - Concord Repatriation General Hospital (2019/ETH11806). Ethical approval is also supplied by Australian Catholic University (2018-279E), Peter MacCallum Cancer Centre (19/175), North Sydney Local Health District - Macquarie Hospital (2019/STE14595), and Alfred Health (516-19).

Consent for publication
Not applicable.

Competing interests
PC is the recipient of a Victorian Government Mid-Career Research Fellowship through the Victorian Cancer Agency. PC is the Founder and Director of EX-MED Cancer Ltd, a not-for-profit organization that provides exercise medicine services to people with cancer. PC is the Director of Exercise Oncology EDU Pty Ltd, a company that provides fee for service training courses to upskill exercise professionals in delivering exercise to people with cancer.

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6.0 CHAPTER SIX: Implementation of physical activity interventions in a community-based youth mental healthcare service: A case study of context, strategies, and outcomes

6.1 Preamble

Chapter 5 provided a detailed rationale and methodology for how an implementation science approach can be applied to understand the implementation process for exercise EBIs in mental illness and cancer. This chapter provides the findings of the first case study, which explored how exercise EBIs are successfully implemented in a mental healthcare organisation, specifically in a community-based youth mental healthcare service.

Impacts of the COVID-19 pandemic on this study

At this point it is important to document the impacts of the COVID-19 pandemic on this thesis. This study was planned as a multiple case study involving three mental healthcare sites and three cancer care sites (refer to Chapter 7). Suitable sites that were identified for this study were located in two different states in Australia (New South Wales and Victoria). Data collection was planned to occur in a staged approach across sites and commenced in November 2019. I completed data collection at two cancer sites prior to the COVID-19 pandemic.

In Australia, many mandates were introduced to stop the spread of COVID-19. This included stay-at-home orders, closures and restricted access to entertainment venues, schools and workplaces and closures to the state borders to restrict travel. The border closure between Victoria and New South Wales meant I was unable to travel to two of the proposed study sites. Healthcare organisations also implemented policies to restrict non-essential access to their sites and face-to-face exercise services were paused. As such, my supervisory team and I modified the approach to this study. This chapter now describes a single case study conducted at a mental healthcare site.

This work has been published:

6.2 Published manuscript

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EARLY INTERVENTION IN THE REAL WORLD

WILEY

Implementation of physical activity interventions in a community-based youth mental healthcare service: A case study of context, strategies, and outcomes

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Abstract

Aims: Physical activity interventions are recommended for community-based youth mental health services to prevent physical health disparities. Implementation is challenging, and studies focusing on the methods to achieve change are needed. This study aims to identify the context, implementation strategies, and implementation outcomes that illustrate how physical activity interventions were implemented within an early intervention service in Australia.

Methods: A theoretically informed case study was undertaken. Data from a community-based youth mental health service that delivers an early psychosis programme were collected between July and November 2020. Three data sources were accessed (1) interviews with service managers, mental health clinicians and exercise physiologists; (2) document review of organizational policies and procedures; and (3) survey using the Program Sustainability Assessment Tool. The implementation outcomes investigated were acceptability, fidelity, penetration, and sustainability. Framework analysis was used, and a logic model developed guided by an established template, to interpret findings.

Results: Forty-three contextual factors and 43 implementation strategies were identified. The data suggests that creating a new clinical team and auditing and feedback are critical for implementation. High levels of acceptability and sustainability were described, while fidelity of implementation was difficult to establish, and penetration was low.

Conclusions: The relationship between constructs suggests several mechanisms underpinned implementation. These include changing professional beliefs, establishing new organizational norms, augmenting existing work processes, and aligning physical activity with priorities of the mental healthcare system and existing work tasks. This case study provides direction for future health service planning of physical activity interventions in community-based youth mental health service.

KEYWORDS

evaluation, implementation outcome, implementation strategy, physical activity, youth mental health

1 | INTRODUCTION

Physical activity (PA) is beneficial for youth experiencing first episode psychosis (Firth et al., 2016; Firth et al., 2018; Parker et al., 2021). Physical activity, as a component of screening and lifestyle interventions, can help address the aetiology of poor physical health that is often detected early in the course of mental ill health (Carney et al., 2016; Correll et al., 2017). Poor physical health, including overweight and obesity, hypertension, insulin resistance and metabolic syndrome, contribute to higher rates of non-communicable disease and reduced life expectancy in people with serious mental illness (Firth et al., 2019). As such, preventative actions including screening and lifestyle interventions, are recommended through early intervention services (Shiers & Curtis, 2014).

Despite evidence suggesting these interventions are acceptable (Firth et al., 2016), feasible (Firth et al., 2018) and implementable in real-world settings (Smith et al., 2020a), an implementation gap exists. Wide-spread uptake and support for service users to engage with physical activity, is low. The implementation gap, that is 'interventions are not implemented with sufficient fidelity and consistency to produce optimal benefits' (Brownson et al., 2017) is a recognized problem in healthcare. Implementation research is a potential response to reduce or close this gap (Czosnek et al., 2020).

Implementation research investigates the methods needed to accelerate the uptake and use of evidence-based interventions (EBIs; such as PA) in routine healthcare practice (Bauer & Kirchner, 2019; Eccles & Mittman, 2006). Critical to implementation research is (1) the clinical or public health problem and the determinants that inhibit or enable implementation of EBIs; (2) identifying implementation strategies to help uptake (e.g., training, reminding clinicians) (Kirchner et al., 2020); (3) measuring implementation outcomes that result from the process of implementation (e.g., fidelity of implementation) (Proctor et al., 2011); and (4) the context surrounding this relationship (Damschroder, 2020). Context typically captures the unique circumstances that influence implementation efforts at a given site (Damschroder et al., 2009; Nilsen & Bernhardsson, 2019). Establishing the relationship between context, strategies and outcomes is important because when this relationship is successful, implementation of EBIs is optimized and people receive best practice care (Proctor et al., 2011). A set of definitions of implementation research terms is provided in Supplementary file 1.

Previous research illuminates the contextual factors influencing implementation of lifestyle interventions (e.g., time, location, transportation, and attitudes of staff; Deenik et al., 2019; Mucheru et al., 2020). However few studies investigate what implementation strategies are used and the outcomes of these efforts (e.g., does training stakeholders improve acceptability of PA interventions? Deenik et al., 2020). Modelling and simulating desirable behaviours is an implementation strategy previously adopted in a community-based youth mental health service (e.g., engaging staff in physical healthcare; Rosenbaum et al., 2020). Whilst other strategies are generally suggested, they have not been identified through empirical studies (e.g., creating academic partnerships, identifying and preparing champions, and involving patients, consumers and family members; Lederman et al., 2017). Separately, outcomes of EBIs have been evaluated, but the same has not occurred for outcomes of implementation (Lederman et al., 2020). To the best of our knowledge, studies have not drawn together the context, strategies, and implementation outcomes to offer a comprehensive and transparent account of the change process involved in implementing PA interventions. This includes detailing the mechanisms that describe how the implementation strategy supported behaviour changes and contributed to successful implementation.

This study aims to address these gaps and answer the following research questions:

1. What context, strategies and outcomes contribute to the implementation of PA interventions within an early psychosis programme (EPP) in a community-based youth mental health service?
2. How can the learnings from a case study help to define what is implementation success?

2 | METHOD

2.1 | Study design

A case study approach was used to gain an in-depth understanding of the implementation process (Yin, 2018). Data from the following sources were collected in parallel: (1) Qualitative semi-structured interviews (with organizational executives, service managers, social workers, psychologists, nurses, accredited exercise physiologists [AEPs]); (2) Document review of organizational policies and procedures; (3) Quantitative survey using the Program Sustainability Assessment Tool (PSAT; Luke et al., 2014).

Three frameworks guided data collection and analysis. The Consolidated Framework for Implementation Research (CFIR; Damschroder et al., 2009) is a determinant framework that consists of 39 constructs organized into five domains that illustrate and prioritize contextual factors. The Expert Recommendations for Implementation Change (ERIC; Powell et al., 2015) is a taxonomy of 73 implementation strategies grouped within nine categories. The Implementation Outcomes Framework (Proctor et al., 2011) is an evaluation framework (Nilsen, 2015) used to measure eight implementation outcomes, four of which are used in this study (acceptability, fidelity, penetration, and sustainability). These four implementation outcomes were selected for measurement in this study as we sought to understand the later stages of implementation (via measurement of acceptability, penetration, and sustainability). Fidelity of implementation was included because of its implicit importance in verifying whether PA was implemented as intended to elicit the anticipated clinical outcomes (Proctor et al., 2011).

An interview guide was developed, informed by the CFIR interview tool, to guide semi-structured interviews (CFIR, 2018). A checklist from case study literature detailed the typical documents that the research team were seeking to collect from the site (Yin, 2018). Finally, the PSAT was selected because it is one of few validated sustainability measurement tools (Luke et al., 2014). It measures an interventions capacity for sustainability across eight domains (environmental support, funding stability, partnerships, programme adaption, communications, organizational capacity, strategic planning, programme evaluation). A case study database was created by the authorship team to maintain and organize the data collection.

Ethical approval for the study was granted by Sydney Local Health District (Concord Hospital) 2019/ETH 11806 and Alfred Health (516/19).

2.2 | Case description

The community-based youth mental health service is in Victoria, Australia. The service delivers an EPP at four different locations, of which the PA interventions are part of that service and the focus of this study. Young people are eligible for EPP if they are aged between 12 and 25 years, have experienced functional decline over the preceding 3 months (e.g., school absence) and are experiencing psychotic symptoms or are at high-risk of symptoms. The EPP provides services to approximately 550 young people at any one time and provides many supports including: reengagement in study and/or employment, relationship support, access to education courses, participation in creative and social activities and facilitating contact with a general practitioner.

2.3 | Data collection

Data collection occurred between July and November 2020. Clinical and administrative personnel from the case site helped locate relevant organizational documents. We interviewed staff who had some knowledge of the PA services delivered within the organization. We purposely selected staff with different job roles to obtain a rounded, organizational perspective of implementation (Greenhalgh et al., 2012). A subset of staff ($n = 3$) completed the 40-item PSAT survey, which is consistent with previous studies using this tool (Kelly et al., 2013; Stoll et al., 2015). The PSAT results are pooled across the three staff to provide an organizational view of programme sustainability that highlights areas of programme strength and weakness (Calhoun et al., 2014; Washington University, 2018).

2.4 | Data analysis

Descriptive statistics were calculated for the PSAT. Qualitative data was uploaded into NVivo 12 (QSR International, 2018) and analysed using framework analysis (Gale et al., 2013). To index and code the data, a coding frame was established a priori that aligned with the frameworks guiding this study. That is, we applied the determinants listed in the CFIR, the implementations strategies listed in ERIC and the four implementation outcomes examined in this study from Proctor's Implementation Outcomes, as codes in NVivo 12. Data were then mapped to the corresponding code and a framework matrix developed. This informed the content of the logic model, guided by an established template, (Smith et al., 2020b) to interpret the findings (Moore et al., 2015; Smith et al., 2020b). The data analysis was led by the first author (LC). An iterative process of review and cross-checking occurred with members of the research team (S.R., N.R., E.Z., J.R.), at scheduled monthly meetings, to produce the final logic model.

Supplementary file 2 provides a summary of the constructs, measures, and corresponding data sources for this study.

3 | RESULTS

3.1 | Description of study participants and data sources

We identified 37 data sources. We completed 10 semi-structured interviews (female $n = 8$, 80%; male $n = 2$, 20%) with staff. Most staff had between 6 and 10 years of experience ($n = 4$, 40%), or greater than 10 years of experience ($n = 4$, 40%). Staff represented diverse roles including: (1) AEP ($n = 2$, 20%); (2) key referral source ($n = 2$, 20%); (3) other health professionals ($n = 4$, 40%); (4) executive ($n = 1$, 10%); and (5) programme manager ($n = 1$, 10%). Three PSATs were competed, and 24 documents were reviewed. Documents included: (1) evaluations ($n = 8$, 33%); public-facing documents (e.g., website; $n = 8$, 33%); (2) administrative resources (e.g., positions descriptions, staff manuals; $n = 6$, 25%); and (4) programme-specific protocols ($n = 2$, 8%).

3.2 | Description of the physical activity intervention

The PA interventions were administered by two AEPs, who service the four locations. On entry to EPP, young people work with a case manager to develop a care and recovery plan. Within this, completing a physical health screen is recommended by 6 weeks of initial service contact. The physical health screen prompts referral to PA services. Young people who are taking psychotropic medications or indicate concern/interest in their weight, sleep or level of activity are offered access to the AEP. Young people can also self-refer to PA service. The AEP conducts an initial assessment with the young person and establishes an individualized PA intervention. This may include a home programme, attendance at a local gym, or participation in walking groups or specialist programmes (e.g., tennis, football, bushwalking). Family members and friends can join the PA services for social support.

3.3 | Context and implementation strategies

Table 1 summarizes the contextual factors and implementation strategies identified with reference to the thematic frameworks (CFIR and ERIC).

3.3.1 | Contextual factors (CFIR)

Forty-three contextual factors were identified, of which 21 were prioritized as highly influential to the implementation process (Table 1). Table 2 provides a description of these 21 factors, of which seven were barriers and 14 were facilitators of the implementation process.

3.3.2 | Implementation strategies (ERIC)

Forty-three implementation strategies were identified across eight (of the possible nine) ERIC categories (Table 1). Table 3 provides a summary of the implementation strategies that are proposed to align with the prioritized determinants.

Supplementary file 3a and 3b provide an expanded explanation supported by relevant data sources for the 43 contextual factors, and a description of the 43 implementation strategies.

TABLE 1 Contextual factors and implementation strategies categorized to thematic frame

Consolidated framework for implementation research (CFIR) (5 domains)	Total number of determinants identified through study	Prioritized determinants[b]
Intervention-level factors (e.g., physical activity)	6	3
Outer-setting level factors (e.g., environment)	4	3
Inner-setting factors (e.g., organization)	19	8
Individual-level factors (e.g., healthcare clinician)	7	3
Process-level factors (e.g., implementation steps)	7	4
Total	43	21
Expert Recommendations for Implementing Change (ERIC) (9 Categories)	**Number of implementation strategies identified within each category *N* (%)[a]**	
Adapt and tailor to context	5 (75.0)	
Change infrastructure	3 (42.8)	
Develop stakeholder interrelations	6 (37.3)	
Engage consumers	6 (100.0)	
Provide interactive assistance	0 (0.0)	
Support clinicians	4 (80.0)	
Train and educate stakeholders	10 (72.7)	
Use evaluative and iterative strategies	8 (60.0)	
Use financial strategies	1 (11.1)	
Total	43	

[a]Within category frequencies are reported for each discrete implementation strategy category.
[b]A list of prioritized determinants can be found in Table 2.

3.4 | Implementation outcomes (implementation outcomes framework)

3.4.1 | Acceptability

Physical activity is acceptable and viewed as a valuable addition to the service. Staff framed their perception in the context of the AEP's delivering the service and its importance for youth – 'Look, I just think…the people who are working within exercise physiology are fantastic workers…' (Interview 05).

Albeit acceptability had been encouraged over time—'But I guess from feedback that I've heard and observation, it's often something

TABLE 2 Description of prioritized contextual factors that influenced implementation

Barriers		
CFIR Domain	CFIR construct	Description within this study
Intervention	complexity	screening for physical health and referral to PA create more work for clinicians
Inner setting	*relative priority*	*physical health slips in the context of dealing with more immediate issues* (e.g., *homelessness)*
	implementation climate	*between team differences exist, which impact physical health screening rates and referral to PA*
	available resources	*there is a view that the AEP role is spread thin due to the number of staff* versus *the number of sites they service*
Individual	knowledge & beliefs about the innovation	clinicians lack exposure to PA in their working career, and therefore have a low affinity with PA
	self-efficacy	some clinicians view screening for physical health and referral to PA as outside their professional scope of practice, as such they lack confidence with the process
	stage of change	the degree to which PA is integrated within normal team operations
Enablers		
	CFIR construct	Description
Intervention	relative advantage	PA provides the solution to actioning the outcomes of physical health screens
	adaptability	PA is tailored to meet young people's needs
Outer setting	patient needs & resources	young people's voices are integrated across the organization (e.g., in individual treatment, service delivery and governance)
	cosmopolitanism	capacity for PA services is built through partnerships with external organizations
	external policy & incentives	a collaborative governance model enables evidence-informed practice, funding, and accountability
Inner setting	networks & communications	a flat hierarchy exists that encourages easy communication amongst staff and leaders
	culture	leaders recognize their responsibility to create a supportive working environment
	tension for change	*tolerance for accepting poor physical health has become untenable and drives change*
	learning climate	*staff are supported to participate in ongoing professional learning opportunities and a safe learning environment has been created*
	leadership engagement	*leaders drive change and value PA*
Process	engaging	case manager and mangers are viewed as the main stakeholders to engage for programme success
	formally appointed internal implementation leaders	*a dedicated role was created with responsibility for physical health*
	external change agents	*high profile individuals and organizations support implementation*
	reflecting & evaluating	systems and processes exist to support ongoing service monitoring

Note: *Italics* = Indicates construct is a sibling within CFIR framework.
Abbreviations: AEP, accredited exercise physiologist; CFIR, consolidated framework for implementation research; PA, physical activity.

that's forgotten about. And exercise physiologists have to push a fair bit…' (Interview 10).

3.4.2 | Fidelity

Quality of programme delivery
The EPP has a service model that includes 16 core components, of which two align with PA (medical interventions and group programmes). Independent fidelity checks were completed against each of the 16 core components, wherein most recently the service achieved superior results, indicating high fidelity to the core components.

Dose/amount of programme
Figures from the 2019/2020 financial year indicate the average number of AEP sessions per person is 38, which includes all attempts to contact. Direct service provision is estimated at between one and 12 sessions. Attendance rates were not routinely captured; however, a snapshot indicates they varied from 45% (January 2020) to 77% (February 2020). The lack of specificity about the activities delivered within the PA interventions means fidelity of implementation could not be confidently determined.

3.4.3 | Penetration

Service system
The level of service integration (2019/2020 financial year) suggests approximately 18% ($n = 253$) of young people accessing the EPP service have sessions with the AEP. Typically, young people who access the AEP have approximately 20% longer duration of contact with the service than the organization average.

TABLE 3 Implementation strategies aligned to prioritized determinants

Category	ERIC strategy	Short description of strategy
Adapt and tailor to context	Promote adaptability	Different types of PA are developed and delivered to young people by trained staff (e.g., AEP)
	Use data experts	A dedicated research position supports clinical staff to conduct ongoing evaluations of services
Change infrastructure	Change record system	PA services are included within electronic medical records and the physical health screening form prompts referral to PA
	Mandate change	Leaders outlined expectation for physical health care
Develop stakeholder interrelations	Develop academic partnership	A formal partnership exists with a local university that supports governance, service quality and can advocate for the service
	Involve executive boards	Regular reporting through governing organizations is established. Reports aggregate information collected through 'quality monitoring tools/system'
	Use advisory board and workgroups	A youth advisory group is established at all sites
	Visiting other sites	Leaders were exposed to PA programmes operating in other jurisdictions during the pre-implementation phase
Engage consumers	Involve patients' consumers and family members	Young people's voices are included in individual treatment, service delivery and strategic planning
Support clinicians	Create new clinical team	A dedicated role exists that is responsible for physical health
	Resource sharing agreement	Partnerships have been established with external PA providers and discount membership fees negotiated with local gyms
	Facilitate relay of clinical data	The AEP attends multi-disciplinary team meetings to discuss young people's care and progress
	Remind clinician	'Educational materials' are used to prompt for physical health screening and referral to PA
Train and educate stakeholders	Conduct educational meetings	Presentations about PA are delivered through whole-of-staff meetings. Staff can engage in one:one learning sessions with the AEP
	Create a learning collaborative	A physical health special interest group has been established that has representation from most teams and workshops implementation issues
	Develop educational materials	The AEP role and functions are detailed within an organizational manual and a flow chart documents the process for physical health screening and referral to PA
	Shadow other experts	During the early implementation phase, staff paired-up to conduct physical health screening
Use evaluative and iterative strategies	Audit and feedback	A system exists to track completion of physical health screens as per procedures, with the results relayed to staff
	Develop and implement tools for quality monitoring	Templates exist that collect clinical and non-clinical data. This information guides individual care and can be aggregated within organizational reports (see involve executive boards)
	Develop and organize a quality monitoring system	A system exists to tracks which case managers are referring to PA (and those that are not)
	Obtain and use patient, consumer and family feedback	Surveys are developed to capture young people's views, and this is fed through to the executive
Use financial strategies	Other payment scheme	The service operates through a commissioning model

Abbreviations: AEP, accredited exercise physiologist; ERIC, expert recommendations for implementing change; PA, physical activity.

Sub-system

Penetration within the sub-system appears high. A staff manual exists that documents the PA services and instructions on how to refer. The PA services are included within the organizations reporting requirements (number of young people seen, type of PA services, workforce issues, and professional development completed) and the organizational budget includes a staffing allocation for PA interventions.

3.4.4 | Sustainability

Table 4 summarizes the PSAT results.

Evolution over time

The domains of *environment support* (5.7 ± 0.8) and *program adaption* (5.5 ± 0.7) achieved the highest scores from the PSAT assessment,

TABLE 4 Results of the Programme Sustainability Assessment Tool (PSAT)

Domain	Definition[a]	Mean[b] (*SD*)
Environmental support	Having a supportive internal and external climate for your programme	5.7 (0.8)
Funding stability	Establishing a consistent financial base for your programme	4.0 (0.9)
Partnerships	Cultivating connections between your programme and its stakeholders	3.8 (1.2)
Organizational capacity	Having the internal support and resources needed to effectively manage your programme and its activities	4.5 (1.1)
Program evaluation	Assessing your programme to inform planning and document results	4.2 (1.5)
Program adaptation	Taking actions that adapt your programme to ensure its ongoing effectiveness	5.5 (0.7)
Communications	Strategic communication with stakeholders and the public about your programme	4.9 (0.9)
Strategic planning	Using processes that guide your programme's direction, goals, and strategies	4.9 (0.9)

[a]Definitions as supplied.
[b]Possible range; 1–7, with higher scores indicating areas of greater programme strength.

indicating areas of programme strength. A key adaption made to the programme that supported implementation sustainability included providing different PA interventions (e.g., developing group and online classes). *Environmental support* including bi-partisan political support and champion roles, which were evident at the site, also supported sustainability—'But there are champions of it and that is the (A)EPs, the practice nurse and (the) physical health portfolio group'. (Interview 02)

Programme components

Partnerships (3.8 ± 1.2) and *funding stability* (4.0 ± 0.9) achieved the lowest scores on the PSAT. This suggests areas for improvement and are directly relevant to the programme components (e.g., maintaining a qualified workforce to deliver the programme and provision of multiple PA opportunities). The service is funded through a commissioning model, which results in some staff turnover due to an inability to provide ongoing employment contracts. Despite this, the organization is viewed as well-resourced.

While PSAT results suggest *partnerships* are an area for improvement, data from other sources does not corroborate this. The document review identified 23 organizations as formal partners of the service.

Health outcomes

No mechanism exists to monitor health benefits of the PA interventions over time which is a recognized service gap—'But the problem is often we don't always know when the end is and so people will get discharged (without assessment by AEP)… and that's something we're trying to fix'. (Interview 02)

Relationship between context, implementation strategies and implementation outcomes

Supplementary file 4 maps the relationship between the context, strategies and outcomes and offers the mechanism for how implementation strategies exert their effect. The mechanisms suggested to underpin change include: (1) optimizing or enhancing existing workflows; (2) building clinicians' knowledge and skills; (3) influencing the social environment within the organization; (4) motivating clinicians to act in a certain way by establishing expected outcomes; (5) establishing processes that align PA with existing organizational workflows and (6) positioning PA as a value-adding solution to broader priorities of the mental healthcare system. A logic model that depicts the process of implementation is provided in Figure 1.

4 | DISCUSSION

This study applies implementation research to understand the integration of PA interventions in a community-based youth mental healthcare service delivering an EPP. Forty-three contextual factors influenced implementation, with a similar number of implementation strategies used to address these determinants. We posit that these actions contributed to various implementation outcomes (acceptability, fidelity, penetration, and sustainability). By combining these concepts, we provide a logic model that illuminates how implementation occurred.

4.1 | Contextual factors

Consistent with previous literature (de Jonge et al., 2020; Denieffe et al., 2021; Happell et al., 2012; McCurdy et al., 2020), healthcare providers lack of exposure to, knowledge about, and skills in discussing PA impacted their intention to act (e.g., screen and make referrals to PA). This was compounded by perceptions that screening and referral processes were complex, added more work and a lower priority than other issues (e.g., homelessness, unemployment). The practical implications of these findings are that implementation strategies that improve clinicians' knowledge and skills alone (e.g., education/training), are unlikely to address the challenges of workload and perceived complexity. Strategies are also required that prioritize physical health (e.g., audit and feedback) amongst other important issues and change social norms (e.g., leaders mandating change).

Organizational leaders played a critical role in prioritizing PA. Leaders allocated resources, prioritized a positive organizational culture and provided protected learning time. The extant literature identifies culture change as important for PA implementation (Rosenbaum et al., 2018). However, to the best of our knowledge only one other study has explored the role of leaders (Cabassa et al., 2020). This is despite their recognized role in influencing implementation success (Albers

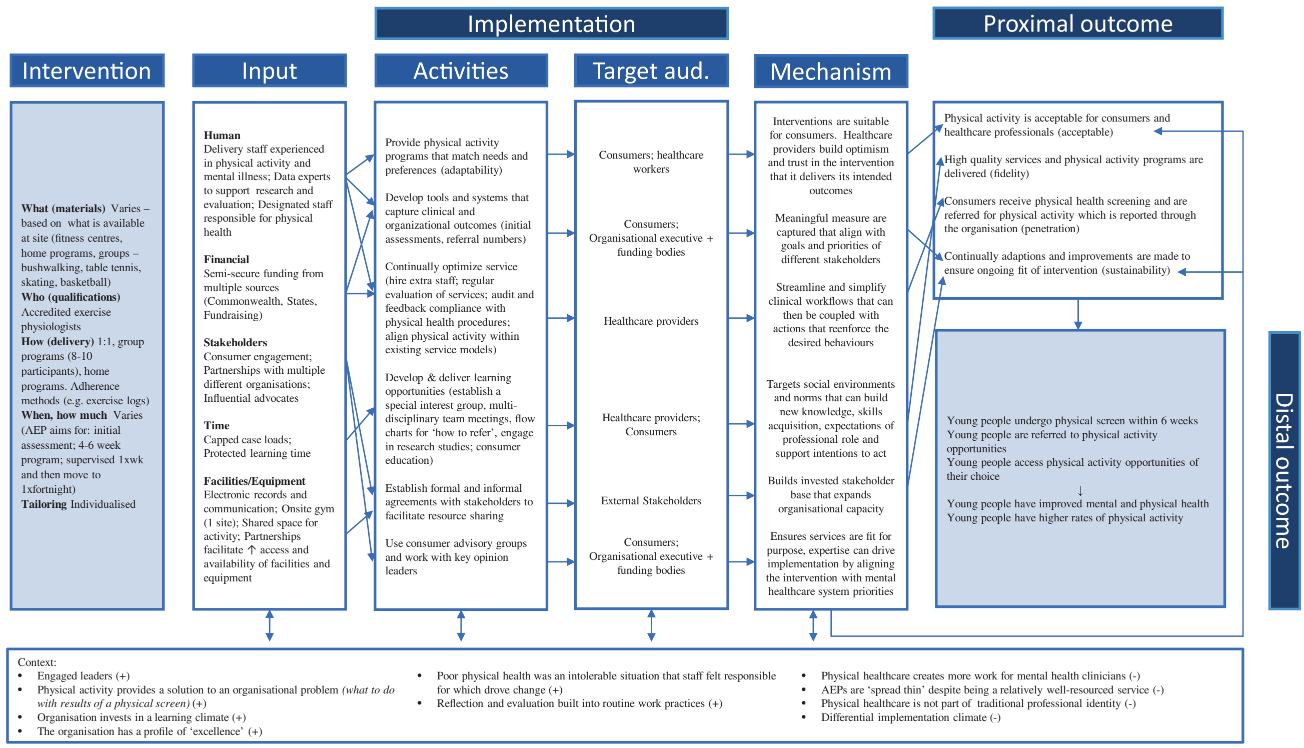

FIGURE 1 Logic model depicting the implementation process for physical activity interventions

et al., 2020; Brownson et al., 2017; Williams et al., 2020). Cabassa and colleagues posit key leadership actions were: (1) securing funding; (2) building organizational capacity; and (3) ensuring lifestyle interventions fit with existing organizational structures (Cabassa et al., 2020). Our study concurs with these findings and extends the knowledge base in PA by showing how the leaders' role can amplify evidence-based practices. This included: (1) embedding monitoring and evaluation in routine work practices; (2) integrating partnerships and workforce development opportunities within organizational reporting; and (3) enabling protected learning time (e.g., physical health special interest group).

4.2 | Implementation strategies

The study site used many implementation strategies, of which *creating a new clinical team* (e.g., adding a new nurse coordinator role) and *audit and feedback* appear critical. These strategies appear critical because they created additional, dedicated resource to coordinate the organizations approach to physical healthcare. This increased support for staff, some of whom, expressed having low exposure to physical healthcare and PA in their working history. Auditing practices, accompanied by strategies that educated and supported clinicians, reinforced the desired behaviour. A recent study that rated the importance of different strategies in relation to metabolic screening in veterans with mental illness, identified 35 strategies as 'absolutely essential' for implementation (Waltz et al., 2021). Many strategies identified by Waltz and colleagues were consistent with our study including: audit and feedback, developing and implementing tools for quality monitoring, identify and prepare champions and mandating change (e.g., leaders with sufficient seniority to enforce change). Further, our study found limited use of financial strategies, which is also consistent with Waltz and colleagues' findings. Taken together, our findings offer insights into strategies that may be appropriate in similar mental healthcare settings. Future studies can build on this work by testing the effectiveness of these strategies, or combinations of strategies, to sustain PA interventions (Powell et al., 2019). For example, by comparing implementation success between services that use a nurse consultant and audit and feedback systems, versus those that do not. This should help identify the dedicated implementation supports required to deliver PA interventions.

4.3 | Implementation outcomes

The evaluation of fidelity evidenced a high-quality service, yet fidelity of programme dose/amount (that is needed to produce clinical outcomes) is unknown. This makes it challenging to determine fidelity of implementation. To resolve this, the record-keeping system could be updated to monitor if the intervention was delivered as planned or adaptations were needed. Second, the service-level penetration (or reach) was relatively low (18%), with people who see the AEP typically having a longer duration of contact with the service. This suggests a potential referral bias exists whereby only those with the most acute needs are being referred to the AEP. Low penetration is potentially being compounded by the individualized delivery model and level of resourcing allocated to the PA services. Combined, these findings suggest a need to explore other delivery models, such as increasing group-based services. The social support that comes from groups

(Shannon et al., 2020; Watkins et al., 2020), may be particularly appealing to youth. Group programming could also improve alignment with recommendations to better protect the good physical health of people who are at-risk, in addition to improving the physical health of people with mental illness (Firth et al., 2019).

4.4 | Relationship between context, implementation strategies and implementation outcomes

Applying case study methodology, we developed an implementation logic model to explain the implementation process. This included detailing the mechanisms that are theorized to bring about change. Identifying mechanisms is an under-studied area of implementation research (Lewis et al., 2020). A recent systematic review identified three previous studies employing case studies methods that identified mechanisms of change (Lewis et al., 2020) Consistent with our findings managerial feedback that *motivated* staff (Frykman et al., 2014), delegating *tasks responsibility* to a particular staff member, ensuring team members understood their colleagues work roles to build *trust* (Wiener-Ogilvie et al., 2008) and augmenting clinical *norms* were identified mechanisms (Bardosh et al., 2017). It is promising that across these case studies consistency in mechanisms is identified. This suggests some confidence can be taken from the learnings of our case study. However, given the limited research in this area replicating our findings is needed, prior to widespread application. Replicability should help future sites develop appropriate implementation strategies (ideally guided by ERIC or similar taxonomy) that identify and include the critical elements of change.

4.5 | Limitations

This study focused on organizational-level implementation and examined service providers perspectives of implementation of their service. We did not engage consumers or families, meaning that the findings need to be verified with service-users prior to application at other sites. The PSAT provides a cross-sectional view of sustainability but does not provide a definitive cut-off point at which sustainability is assumed. Further, the measures identified to evaluate the implementation outcomes were reliant on availability of data at the site. In some instances, this data was inaccessible, or incomplete. For example, results for service level penetration were calculated based on data supplied by the organization, however this data was not routinely collected and analysed by the service. Finally, due to COVID-19 we were unable to undertake onsite observations as initially intended.

5 | CONCLUSION

Few studies identify context, implementation strategies, implementation outcomes and relationship between these factors to articulate how implementation occurs. We found many factors appear inter-related and multiple strategies were in-use to support effective delivery of PA. We suggest strategies that allocate direct responsibility for physical healthcare to a specific person or team is essential for effective implementation (e.g., nurse coordinator role). This is separate to hiring staff that have the required skills to deliver PA (e.g., AEP). To achieve this, leaders have a critical role in realigning or creating resources. To build on our work, future studies could: (1) test the effectiveness and cost of the implementation strategies identified (Powell et al., 2019); (2) routinely evaluate implementation outcomes within pragmatic trials to measure implementation success (Shepherd et al., 2019); and (3) build change processes that allow empirical testing of implementation components to identify the most effective bundles that lead to successful implementation (Lewis et al., 2018). Building on our work will contribute to more efficient, targeted implementation planning that can help introduce PA in youth mental health services and ultimately improve care.

CONFLICT OF INTEREST

Prue Cormie is the recipient of a Victorian Government Mid-Career Research Fellowship through the Victorian Cancer Agency. Prue Cormie is the Founder and Director of EX-MED Cancer Ltd, a not-for-profit organization that provides exercise medicine services to people with cancer. Prue Cormie is the Director of Exercise Oncology EDU Pty Ltd., a company that provides fee for service training courses to upskill exercise professionals in delivering exercise to people with cancer.

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DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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7.0 CHAPTER SEVEN: *"Now is the time for institutions to be investing in growing exercise programs as part of standard of care"*: A multiple case study examining the implementation of exercise oncology interventions

7.1 Preamble

The previous chapter identified the context, implementation strategies and implementation outcomes that illustrate how exercise EBIs can be successfully integrated within a youth mental healthcare service. The aim of this chapter was to explore the implementation process of exercise EBIs in cancer care. This chapter provides the findings of the second case study completed through this thesis, which was a multiple case study involving three cancer care sites that had successfully implemented exercise oncology services.

This work has been published.

7.2 Published manuscript

Czosnek L, Rankin N, Cormie P, Murnane A, Turner J, Richards J, Rosenbaum S, Zopf, EM. *"Now is the time for institutions to be investing in growing exercise programs as part of standard of care":* A multiple case study examining the implementation of exercise oncology interventions. *Supportive Care Cancer*. 2023 June 26;31(7):422. Doi: 10.1007/s00520-023-07844-x.

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RESEARCH

"Now is the time for institutions to be investing in growing exercise programs as part of standard of care": a multiple case study examining the implementation of exercise oncology interventions

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Abstract

Background Implementation science seeks to systematically identify determinants, strategies, and outcomes within a causal pathway to help explain successful implementation. This process is applied to evidence-based interventions (EBIs) to improve their adoption, implementation, and sustainment. However, this method has not been applied to exercise oncology services, meaning we lack knowledge about implementing exercise EBIs in routine practice. This study aimed to develop causal pathways from the determinants, strategies (including mechanism of change), and implementation outcomes to explain exercise EBIs implementation in routine cancer care.

Methods A multiple-case study was conducted across three healthcare sites in Australia. Sites selected had implemented exercise within routine care for people diagnosed with cancer and sustained the delivery of services for at least 12 months. Four data sources informed the study: semi-structured interviews with staff, document reviews, observations, and the Program Sustainability Assessment Tool (survey). Framework analysis was applied to understand the findings. The Implementation Research Logic Model was used to identify commonalities in implementation across sites and develop causal pathways.

Results Two hundred and eighteen data points informed our findings. Across sites, 18 determinants and 22 implementation strategies were consistent. Sixteen determinants and 24 implementation strategies differed across sites and results of implementation outcomes varied. We identified 11 common pathways that when combined, help explain implementation processes. The mechanisms of implementation strategies operating within the pathways included (1) knowledge, (2) skills, (3) secure resources, (4) optimism, and (5) simplified decision-making processes associated with exercise; (6) relationships (social and professional) and support for the workforce; (7) reinforcing positive outcomes; (8) capability to action plan through evaluations and (9) interactive learning; (10) aligned goals between the organisation and the EBI; and (11) consumer-responsiveness.

Conclusion This study developed causal pathways that explain the how and why of successful implementation of exercise EBIs in cancer care. These findings can support future planning and optimisation activities by creating more opportunities for people with cancer to access evidence-based exercise oncology services.

Implications for cancer survivors Understanding how to implement exercise within routine cancer care successfully is important so cancer survivors can experience the benefits of exercise.

Keywords Exercise · Implementation · Cancer · Physical activity · Evaluation

Introduction

Medical advances in cancer screening, diagnosis and treatment mean people are living longer after a cancer diagnosis [1, 2]. As life expectancy increases, efforts to optimise the quality of a longer life are critical. Exercise is an evidence-based intervention (EBI) increasingly employed across the cancer care continuum [3]. Exercise is applied to prevent cancer, better prepare people for cancer treatments, ameliorate the disease sequela associated with its treatment and improve life after a cancer diagnosis [4, 5].

Despite a substantial evidence base and recommendations within clinical practice guidelines [4, 6, 7], exercise is not routinely integrated into cancer care during and after treatment completion [8]. This is not entirely unexpected, as

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successful implementation of EBIs in healthcare is notoriously difficult, with many complex factors at the patient, provider, organisational and health system levels influencing uptake [9–11]. The methods employed in the discipline of implementation science are used to improve understanding and help explain the outcomes and success of the implementation process [12].

Implementation science applies a sequential and structured approach to produce generalisable knowledge [13]. Developing generalisable knowledge encourages the replication of critical findings across sites/context to help spread effective EBIs. It can also be applied prospectively to understand the extent to which results are transferable to other settings (i.e., transferability of findings) [14]. Several implementation science constructs are recognised and enable transferability, including (1) determinants (i.e., barriers and facilitators) that shape the contextual environment and influence the implementation process [15, 16]; (2) implementation strategies, which are the actions applied to augment the contextual environment and create favourable conditions for implementation [17–19]; (3) implementation outcomes of these efforts to define and measure whether successful implementation was achieved [20, 21]; and (4) mechanisms of change, which are the "processes or events through which an implementation strategy operates to affect desired implementation outcomes" [22]. Implementation research has tended to study these constructs in isolation; however, greater emphasis is now focused on the combined analyses to explain how these constructs operate together [23]. Combined analysis can include sequentially linking these constructs to elucidate the explanatory causal pathway and hypothesised mechanisms contributing to successful implementation [24–27]. Without this combined analysis, the ability to understand or explain the implementation process and how impact can be achieved on a larger scale is compromised [23].

In cancer care settings, the determinants of exercise EBIs are well studied [28–31]. A recent scoping review systematically identified 243 barriers to implementing exercise oncology EBIs, including limited time during consultations, dedicated exercise resources, and funding [32]. Studies of implementation strategies in exercise oncology are less common [33–36], despite a recent review identifying that using implementation strategies resulted in greater uptake of exercise than if these strategies were absent [37]. Evaluations of implementation outcomes have shown mixed results in understanding what constitutes success [38–41]. To our knowledge, only one study in exercise and cancer has sought to explain the mechanisms for how an implementation strategy is proposed to enact the change function [42]. Research on exercise EBIs in cancer care would benefit from integrating these constructs within a research study to improve targeted implementation efforts and support transferability to increase impact at scale. This study aimed to address this gap by developing explanatory causal pathways for implementing exercise in routine cancer care. We aimed to systematically identify the determinants, implementation strategies (including mechanisms of change), and implementation outcomes for exercise EBIs in cancer care based on established implementation science frameworks [15, 17, 20]. We used a multiple case study design to elucidate commonalities in pathways across cancer healthcare sites. The constructs were linked using the Implementation Research Logic Model (IRLM) [26] to produce the causal pathways.

By testing this approach, we sought to identify the transferable elements that could be relevant in future implementation efforts. The specific objectives of the study were to:

- Identify the commonalities and differences in determinants, implementation strategies and implementation outcomes (acceptability, fidelity, penetration, and sustainability) across exercise oncology services
- Develop an explanatory causal pathway for the implementation processes from the common elements that exist across case sites

Method

Study design and participating sites

The methods and theoretical application of this study have been previously described [43]. Briefly, a multiple case study [44] of implementation was conducted at three healthcare sites across New South Wales and Victoria, Australia. Sites had implemented exercise within routine care for people diagnosed with cancer and sustained service delivery for at least 12 months. We examined the exercise EBIs that were operating at each site.

Case descriptions

Case site A

Case site A is a publicly funded healthcare facility in New South Wales (NSW), Australia. It delivers specialist clinical services across various disciplines including cardiology, mental health, orthopaedics, and oncology. The organisation is also an established learning and teaching institute with research affiliations. The exercise EBI is delivered through the cancer survivorship service. The survivorship service was established in 2013 and is accessible to anyone who undergoes active cancer treatment at the site. Upon entry to the service, patients undergo an initial review with members of a multi-disciplinary team that includes an oncologist, nurse, psychologist, dietitian, and accredited exercise physiologist (AEP). The multi-disciplinary team then develops a holistic treatment plan. Multiple services are accessible through the survivorship program including individual consultations with allied health professionals, community-based group exercise programs, or participation in classes and workshops. Classes include yoga, art therapy, meditation, QiGong, and scrapbooking. Patients who undergo an initial assessment with the survivorship team can continue their medical treatment with the survivorship service or return to their original medical team for ongoing care. Approximately one-third of patients continue their care with the survivorship team for up to 5 years.

Case site B

Case site B is a community-based not-for-profit organisation in Victoria, Australia. The service commenced as a research project funded by the Victorian State Government. Through the initial funding, a company that continues to deliver exercise EBIs for people with and living after a cancer diagnosis was established. The service operates as a user-pay model that subsidises 50% of the EBI costs through donations/fundraising and, where possible, accessing the universal healthcare system in Australia (Medicare). Case site B delivers the exercise EBI at five locations across metropolitan Melbourne (Victoria, Australia). Several factors were considered in selecting sites, including accessibility, ambience, and amenities. That is close to public transport, car parking and a coffee shop and facilities to conduct private clinical assessments and opportunities to participate in different exercise modalities. The delivery sites are owned and operated by third parties. People access the service through self-referral or referral from sources such as their workplace, health insurer, or medical team. On referral, an initial assessment is completed by an AEP and an individualised exercise plan is developed.

Case site C

Case site C is a publicly funded healthcare facility established with the sole purpose of treating cancer. The main campus is in metropolitan Melbourne, with four satellite sites located in local neighbourhoods and regional areas across Victoria, Australia. Case site C delivers adult cancer services through 13 cancer streams and operates a dedicated youth service. Exercise EBIs are provided for both adults and youth via different service models. For adults, the exercise EBI is situated within a multi-disciplinary prehabilitation program (i.e., a program that focuses on improving physical, emotional, nutritional, and general health before patients commence cancer treatment) and as a standalone allied health service that inpatients and outpatients can access. The prehabilitation program includes a comprehensive assessment and an established care plan that contains interventions from various disciplines (i.e., psychology, dietetics, AEP). The stand-alone allied health service typically offers limited sessions and supports on-referral to exercise opportunities in the community where possible. In the youth service, the exercise EBI is delivered by an AEP who is part of a multi-disciplinary team providing for the health and well-being of youth during and in the years after a cancer diagnosis.

Supplementary file 1 details the exercise EBI delivered at each site.

Data sources

Four data sources informed the explanation of implementation: [1] in-depth semi-structured interviews with purposely selected staff; [2] observational visits to the healthcare sites; [3] review of organisational documents; and [4] a validated survey that assesses the EBIs capacity for sustainability (Program Sustainability Assessment Tool (PSAT)) [45]. An interview guide was developed to help focus inquiry through the semi-structured interviews. Staff selected for the interviews represented a cross-section of roles (i.e., delivery staff, organisational executive) to enable comprehensive formation of the implementation process at each site. Observational visits focused on observing how the exercise EBI was delivered within the broader context of the healthcare sites typical operations. The research team asked questions and sought clarification of what was being observed, however, did not interrupt typical exercise programming. Organisational documents sought for review included items such as program-specific protocols, administrative documents, and consultancy reports. A list of typical documents sought was provided to sites by the research team to help identify relevant documents. Finally, the PSAT measures sustainability across eight domains (i.e., environmental support, funding stability, partnerships, organisational capacity, program evaluation, program adaption, communications, and strategic planning) and provides insights into EBIs' strengths and weaknesses. A sub-set of staff who participated in interviews also completed the PSAT, aligned with the tools recommended use [46, 47]. A case study database was maintained to house and organise data.

Implementation science frameworks and program logic

Three frameworks and a program logic were applied to guide different aspects of the study. The Consolidated Framework for Implementation Research (CFIR) was used to identify and prioritise determinants at each site [15]. The strength and valance coding of the CFIR guided prioritisation [48]. The Expert Recommendations for Implementing Change (ERIC) was the taxonomy applied to provide a consistent description of implementation strategies used at each site [17] and the Implementation Outcomes Framework was used to define the outcomes of interest for this study (acceptability, fidelity, penetration, and sustainability) [20]. As the study was concerned with implementation in routine practice, we selected outcomes recommended for measurement in the later stages of implementation [20]. The program logic used to link these frameworks was the IRLM [26].

Supplementary file 2 summarises the conceptual and measurement framework of the study.

Data analysis

Descriptive statistics were calculated for the PSAT using IBM SPSS Statistics for Windows, Version 28 [49] to obtain one measure of sustainability per site. These findings were uploaded into NVivo software Version 12 [50], together with other data sources, and framework analysis was undertaken to make sense of the data [51]. Framework analysis includes 5 stages (i.e., familiarisation, identifying themes, indexing, charting, and mapping and interpretation), with the approach to data analysis shifting between deductive and inductive reasoning [52]. A deductive approach was adopted through earlier stages when data was indexed and charted directly to the elements of the CFIR, ERIC and Implementation Outcomes frameworks. Analysis shifted to an inductive approach when the IRLM was used to map and interpret the findings and produce a simplified logic model for each site that reflected the prioritised determinants. Finally, the IRLM provided the architecture for the cross-case analysis. The mechanisms of the implementation strategies were identified with reference to relevant literature [16, 53, 54]. The final step in the analysis was to combine each simplified IRLMs into one logic model by drawing out the common elements through inductive reasoning that contributed to the successful implementation of the exercise EBIs across case sites.

Results

Data sources

We collected 218 data points to inform the findings, which included 18 semi-structured interviews, approximately 95 hours of observations, 13 responses to the PSAT and 92 document reviews. Table 1 provides a breakdown of data points across case sites.

Determinants

The number of determinants ranged from 33 to 44 across sites. We identified 18 determinants that were thematically

Table 1 Data sources accessed at each case site

Data sources	Case site A	Case site B	Case site C
Interview			
Accredited exercise physiologists (delivery staff)	1	2	3
Program manager	1	1	2
Referral source	1	1	1
Other allied health staff	1	0	2
Executive	1	1	0
Total	**5**	**5**	**8**
Observational visits			
Number of hours spent onsite	40	40	15
Total	**40**	**40**	**15**
Survey (Program Sustainability Assessment Tool)			
Number completed at each case site	3	4	6
Total	**3**	**4**	**6**
Documents			
Program-specific protocols (i.e., exercise templates)	9	3	19
Consultancy reports (i.e., workforce reports)	2	0	0
Summaries of program achievements (i.e., formal and informal evaluations)	2	5	4
Public-facing documentation (i.e., website, newsletter, strategic plans)	10	4	3
Administrative documents (i.e., staff training, funding, position description, meeting minutes)	10	16	5
Total	**33**	**28**	**31**
Overall total	**81**	**77**	**60**

The bold is used to indicate the total for each section in the table consistent across sites. Most (88.9%, n=16) were categorised as facilitators of implementation, and two (11.1%) determinants were categorised as barriers to implementation efforts. Table 2 provides a summary of the 18 determinants that were similar across sites.

Sixteen determinants were identified that differed across sites. This included differences where some sites identified a determinant as a barrier while others recognised the same determinant as a facilitator of implementation (i.e., two sites viewed the lack of leadership engagement as a risk to the sustainability of exercise EBIs, while one site reported leaders were highly engaged and committed to EBI success). Five determinants listed in the CFIR were not identified at any locations. Supplementary file 3 summarises these determinants.

Implementation strategies

Across case sites, the number of implementation strategies in use ranged from 36 to 44. We identified 22 implementation strategies that were consistent and in use across all case sites. Table 3 describes the consistent implementation strategies across sites, including strategies such as promoting adaptability, changing record-keeping systems and developing a quality monitoring system. Further, 24 implementation strategies were different across sites and 27 implementation strategies listed in ERIC were not adopted by any site (Supplementary file 4).

Across case sites, the highest proportion of implementation strategies fell within the ERIC category of engaging consumers. All five strategies from this category were identified and in use at every case site (i.e., increase demand, intervene with patients, consumers to enhance uptake and adherence, involve patients consumers and family members, prepare patients and consumers to be active participants, use mass media). In contrast, the lowest proportion of implementation strategies were categorised as use of financial strategies. Of the 11 strategies listed within this category, only two were identified and used by all case sites (i.e., access new funding, place innovation on a fee for service list).

Implementation outcomes

Acceptability

Exercise services were reported as acceptable; however, the degree of acceptability varied. At one site, acceptability was directly linked to the individual characteristics of delivery staff. Colleagues respected and valued the AEP personally and the service they offered.

> "And we have a lovely AEP, and I think thanks to (them), generally speaking, it's actually very well received." (Int-5)

In contrast, findings from another site suggested exercise EBIs were more acceptable when embedded with a multi-disciplinary program (i.e., survivorship program, prehabilitation program or multi-disciplinary youth service). However, there was a prevailing view that exercise alone was not a core cancer service.

> "I don't think it's truly being endorsed at an organisational level, particularly within (service name). It's often thought of as a top-on service that would be nice but is not really endorsed." (Int-15)

Fidelity

Fidelity of implementation considered adherence to the EBI protocol, measured across two constructs:

Quality of service delivery

Two sites facilitated formal and informal learning opportunities and technical assistance to ensure staff maintained high-quality service delivery. One site required staff to undergo standardised training in exercise and cancer. The training program provided up to 12 hours of online content and was supplemented with approximately five hours of face-to-face training. Although fidelity of implementation was assumed through the provision of training and technical assistance, we did not identify evidence to suggest that the quality of the resulting service was monitored through formal mechanisms.

Dose/amount of program

EBI dose varied across sites from 15 to 39 contact hours, ranging from 8 to 26 weeks. It was only possible to determine fidelity for one element of the service at case site C. Two sites had completed evaluations to measure fidelity of implementation, and, in both cases, greater than 80% compliance with the EBI protocol was achieved. Further, one site had an ongoing process (via the electronic medical records (EMR)) for measuring adherence to the program protocol. This was documented for individual patients according to the criteria >75%, between 50 and 75% or <50% adherence. At the time of the case study assessment, however, it was not possible to aggregate this information to obtain a measure of fidelity due to data entry errors.

Table 2 Descriptive example of consistent determinants identified across sites using the Consolidated Framework for Implementation Research

Domain	Construct	Description of determinant	Example
Intervention	Evidence strength and quality (E)	Research is used to build buy-in and support for exercise EBIs.	*At (case site name) exercise is an adjunct therapy embedded in standard cancer care. We follow the COSA position statement that recommends patients with a history of cancer should avoid inactivity and:* *Engage in at least 150 min of moderate intensity or 75 min of vigorous intensity aerobic exercise per week (jogging cycling swimming)* *engage in 2–3 resistance exercise sessions per week, targeting major muscle groups (i.e. lifting weights)* — (DR-33)
	Relative advantage (E)	Over time the perceived benefits of exercise have grown and it is seen as the *most effective* treatment for many side effects of cancer treatment.	*"It's a bit of a panacea to everything"* (Int-4)
	Adaptability (E)	The workforce adapts: - The exercise EBI to suit patient preferences; and - The referral process to suit referral sources needs	*"it (exercise) is just an evolving thing. We work with the clinicians and how they like to work and I think that is how we (are) successful…."* (Int-1) *"originally, we didn't run group programs, we used to run individual sessions…one of the biggest changes was with the duration of the intervention…"* (Int-2)
	Trialability (E)	The exercise EBI commenced through a research trial.	*"It is slightly different now because originally it was a research trial."* (Int-6)
Outer setting	Patient need and resourcing (E)	The mechanisms exist to embed the patient voice within EBI design and delivery (i.e., through advisory groups and satisfaction surveys). This includes being responsive to patient direction and making adaptions to the EBI (see *adaptability*).	*"we established a youth advisory board…who come together to advise us on all issues to do with… cancer, not just for us as a service, but they also report up through to State government. So they're actually advising and guiding on policy as well."* (Int-14)
	Cosmopolitan (E)	The organisation develops relationships with other organisations to build capacity of the exercise EBI (i.e., on referral of patients when the service reaches capacity).	*"So, we do have a longstanding relationship with a certain institution…they had a common interest in cancer and then from there, they had the capacity to take more referrals over."* (Int-2)
	External policy and incentives (E)	The COSA position statement on cancer and exercise helped validate the role of exercise in standard cancer care. State government policies reference exercise, which provides strategic policy alignment.	*"The reason that we could establish it was because of the policy of the (State government name) cancer policy to support survivorship. I would say that certainly helped us (and) the COSA position statement and the advocacy and awareness that have come around that."* (Int-9)

Table 2 (continued)

Domain	Construct	Description of determinant	Example
Inner setting	Networks and communications (E)	Strong connections existed between individual staff and within teams that facilitated efficiencies in working relationships and implementation (i.e., corridor conversations, call/email (in place of following formalised procedures)).	*"The other thing is having a personal relationship is actually good. Yeah, we work as a team. I think we know each other pretty well."* (Int-5)
	Implementation climate (E)	Organisations expect innovation and to be a leader in cancer, which allowed the exercise EBI to grow and transform, despite difficult conditions.	*"I think it can be challenging implementing innovative programs in a time of austerity. With that said I think there is a lot of passion and commitment."* (Int-1)
	Compatibility (E)	Systems are implemented (i.e., opt-out referral, IT system coordination and EMR) to ensure exercise EBIs fit and are aligned with existing workflows.	*"We have an opt-out model of care…. so everyone that gets referred into the service will be offered exercise physiology throughout the course of their treatment."* (Int-11)
	Learning climate (E)	Healthcare staff feels supported to seek out new and better ways to integrate evidence/learning in routine practice.	*"There is no expectation that you know, everything. You know, we want to be learning and growing together as a team to make sure that we can deliver the best quality service."* (Int-9)
	Available resources (B)	Healthcare providers lack of time, which is a byproduct of lack of funding, is a barrier to growing/optimising the exercise EBI.	*"We need more, we need more space, we need more (AEPs), we need more time, we don't think enough of that…. we could do with more admin support to help with programs that we are all running."* (Int-4)
	Access to knowledge and information (E)	Healthcare providers aim to create a one-stop shop for exercise and cancer. This means referral sources have easy access to the information they need.	*"I guess I found it difficult to know who to refer to….and to try and find people to refer to is actually quite hard. And so I'd refer people to (organisation name)…. its got a website... and then it's done, it's very quick. I don't have to send an e-mail or anything like that, it's done then and there."* (Int-10)
Individual	Self-efficacy (E)	Healthcare providers are confident to raise and discuss exercise with patients, akin to how they talk about other treatments. Albeit there are *laggards* who don't see it as their role.	*"So, a lot of the patients… they are very surprised to hear me talking about exercise when they have just been diagnosed with say breast cancer…. And I am sort of saying well actually there is all this evidence and I have seen patients (with) … very similar cancer and treatments that you're having and I am going to start prescribing exercise with chemotherapy."* (Int-4)
	Individual stage of change (B)	Providers are aware of the value of exercise, but they do not routinely act to discuss/refer for exercise. They make decisions about *timing* and what are the highest priorities for discussion at that stage of treatment. This is negated with *opt-out* systems.	*"When you meet new people, they've usually got a hell of a lot going on. And is that the right time to talk about exercise?"* (Int-17)
	Other personal attributes (E)	Healthcare providers are committed, passionate and do more than is typically expected of their role (particularly evident of exercise delivery staff).	*"Everyone's got the same passion for what we're doing and that goes along way."* (Int-7)

Table 2 (continued)

Domain	Construct	Description of determinant	Example
Process	Champion (E)	A champion exists who is influential with executives, peers and their direct reports. They use this influence to advocate for increased resources and funding. Champions also build other advocates (i.e., patients and peers) so there is a sense of *unity* in messaging around exercise EBIs and cancer.	*"My line manager is the best support champion of this program and has been the driver for this expanding over the years."* (Int-2)
	Reflecting and evaluating (E)	Procedures are established to monitor and evaluate the implementation process, albeit this is not conducted in a systematic way. Sites use the information as needed to create the story they need to tell at that time.	*"So, when you start to see those patterns where either your activities are going up, wait lists are blowing out, a certain type of service is required because it's getting requested, etc. That's generally the driver behind pulling that data and doing a business case."* (Int-16)

B Barrier, *COSA* Clinical Oncology Society Australia, *DR* document review, *EBI* evidence-based intervention, *EMR* electronic medical record, *E* enabler, *NA* not applicable

Penetration

The integration of the EBI within an organisation was measured at a service and sub-system level:

Service level

Service level penetration (calculated as eligible people who use the service/total number eligible) varied across sites from 17.2 to 80.6%. At the site with low penetration, the service model had recently been altered to improve penetration (i.e., more exercise EBI sessions added at different times to better meet demand). At the site with high penetration, an "opt-out" referral system for the exercise EBI operated (i.e., patients were automatically allocated to undergo a review with the AEP, for participation in exercise, as part of standardised intake assessments).

Sub-system level

Sub-system level penetration was high across sites. All sites had established dedicated role/s for delivering exercise EBIs documented in position descriptions. Outcomes from the exercise EBI were captured in organisation-wide reporting alongside other key performance indicators. One site had recently participated in statewide workforce planning to determine the long-term staffing requirements for people skilled and capable in exercise prescription. Two sites documented the exercise EBI within standard operating procedures (i.e., patient intake assessment procedures).

Sustainability

The extent to which the EBI was maintained and institutionalised within ongoing, stable operations at sites was evaluated according to ongoing program components, evolution over time, and a process in place to measure continued health benefits.

Program components and evolution over time

Program components that evolved over time were assessed primarily using the PSAT and secondly through interviews. The domains with the highest scores across sites were program adaption (M=5.8, SD $\pm$ 0.8), environmental support (M=5.3, SD $\pm$ 1.3) and program evaluation (M=5.0, SD $\pm$ 1.3). The domains with the lowest scores across sites were partnerships (M=4.2, SD $\pm$ 1.5), funding stability (M=4.3, SD $\pm$ 1.2), and strategic planning (M=4.6, SD $\pm$ 1.4). Within domain scores at individual case sites ranged from a low of 2.2 (partnerships, case site C (adult)) to a

Table 3 Descriptive example of consistent implementation strategies identified across sites using the Expert Recommendations for Implementation Change taxonomy

Adapt and tailor to context	
Promote adaptability	Referrals are accepted through multiple mediums (i.e., email, phone, and formal referral forms). Multiple different types of exercise are available and offered to patients.
Change infrastructure	
Change record system	Systems (i.e., EMR) are changed, updated or developed to ensure that exercise is included and monitored, consistent with other cancer treatments.
Develop stakeholder interrelations	
Develop academic partnerships	Academic partnerships are used to initiate services. Academic partnerships continue to be developed to trial new interventions, expand existing services and support quality improvement efforts.
Identify and prepare champions	A champion exists who advocates for the exercise EBI. Typically this person is determined, respected in their field and able to transcend hierarchal structures to influence across the system (i.e., to influence delivery staff, organisational executives and policymakers).
Inform local opinion leaders	Influential people (i.e., specialists, nurses and (where position exists) care coordinators) are identified and engaged to promote exercise EBI. They promote the EBI via speaking roles at forums, testimonials in marketing materials, or because they have a *seat* at the executive table.
Involve executive boards	Status/progress reports that document the impact of exercise EBIs are developed and fed through to the executive level. The purpose of this is to secure buy-in for the EBI and support requests for increased resourcing.
Promote network weaving	Organisations facilitate opportunities for staff to network (i.e., social events, multidisciplinary meetings) and build relationships across disciplines. These relationships are leveraged by staff to create efficiencies in workflows (i.e., *corridor conversations* to prompt referrals and dovetailing clinical appointments to create a seamless service for patients).
Engage consumers	
Increase demand	Consumer activism is fostered so that patients demand and act for the exercise EBI (i.e., involved in public presentation, drafting policy documents and leading petitions for the service).
Intervene with patients, consumers to enhance uptake and adherence	Multiple strategies are applied to enhance adherence to exercise EBIs (i.e., regular phone calls, maintaining an exercise diary, providing home exercise programs (i.e., using Physitrack), use of technology (i.e., tracking exercise via apps/pedometers) and organising social coffee catch-ups amongst patients).
Involve patients' consumers and family members	Patients are engaged with implementation efforts via fundraising initiatives and raising the profile/value of the service (see *increase demand*).
Prepare patients and consumers to be active participants	A *soft-entry* approach is adopted across EBIs where the first contact offers a light-touch introduction to exercise. This aims to build the patients capacity and ownership over their involvement in the exercise EBI.
Use mass media	Organisations use mass media sources (i.e., social media, websites, print media) to raise awareness about the exercise EBI.
Provide interactive assistance	
	Strategies were not identified from this category that were consistent across sites.
Support clinicians	
Develop resource sharing agreements	Formal and informal relationships are established with community-based exercise services. These agreements are used to facilitate referral to other exercise programs in the area if the existing program is at capacity, or to offer an alternate exercise service if the core program does not meet consumer needs.
Facilitate relay of clinical data to providers	Clinical information about the patient's engagement and progress through the exercise EBI is relayed to referral sources at regular intervals.
Train and educate stakeholders	
Conduct ongoing training	The workforce has access to regular ongoing training in cancer care (i.e., via journal club, professional development courses and one-off training courses in exercise oncology).

Table 3 (continued)

Develop educational materials	Organisations use a range of educational materials to support the delivery of exercise EBIs (i.e., exercise recommendations for managing fatigue, referral prioritisation forms, how to refer form, *scripts* that guide new staff in how to deliver a *typical* exercise EBI session).
Distribute educational materials	Dissemination of educational materials typically occurs via email blasts and regular internal communication channels (i.e., newsletters).
Use evaluative and iterative strategies	
Develop and implement tools for quality monitoring	Templates are developed that guide clinical and operational aspects of the EBI (i.e., initial assessment and re-assessment forms that guide subjective and objective assessments and established care plans, exercise programming forms, consumer attendance records, forms to track referral rates to programs).
Develop and organise a quality monitoring system	A system is developed (i.e., tracking through Excel or EMR) that pools the individual data collected through the quality monitoring tools to track the overall impact of the EBI. This information is used for corporate reporting, to develop business cases and to advocate for the EBI (see *involve executive boards*).
Obtain and use patient, consumer, and family feedback	PROs are collected typically via surveys or focus groups prior to a patient's involvement in the program to inform the EBI content. Post-program satisfaction with the service is captured.
Use financial strategies	
Access new funding	Diverse funding sources are pursued to deliver exercise EBI. This includes funding from grants, donations, philanthropic organisations and fundraising efforts.
Place innovation on fee for service list	Delivery staffs are allied health professionals (AEPs/physiotherapists), with their services funded through the universal healthcare systems in Australia (Medicare) or activity-based funding (for in-hospital care).

AEPs Accredited exercise physiologists, *EBI* evidence-based intervention, *EMR* electronic medical record, *PROs* patient-reported outcomes

high of 6.3 (program adaption, case site B). Across sites, the highest mean sustainability score was achieved at case site B (M=5.4, SD ± 0.4), and the lowest sustainability score was achieved at case site C (adult) (M=3.7, SD ± 1.7). Table 4 summarises the PSAT findings at each site and across sites.

Continued health benefits

All sites had a process to monitor individual health outcomes of the EBI. The information on health outcomes was typically aggregated for research papers, business case development (i.e., to request an increase in resources), or for corporate reporting. Historical evaluations of exercise EBIs indicated that across sites and various health measures (i.e., improvement in function and quality of life, reduction in fatigue, anxiety, or depression, and meeting exercise guidelines), participation resulted in health benefits. For example, one site reported a mean 21 percentage point increase in people meeting aerobic exercise guidelines and a 24 percentage point increase in the number of people meeting resistance exercise guidelines after 12 months. A second site reported a mean reduction in cancer-related fatigue (21%), anxiety and depression (8–12%), and improvement across various quality of life domains (7–14%).

Implementation Research Logic Model

From the prioritised determinants, implementation strategies (and corresponding mechanisms), and implementation outcomes, a simplified IRLM was produced for each site (Supplementary file 5). By comparing and contrasting findings across the IRLMs, 11 common implementation pathways were developed that combined explain the implementation process (Fig. 1). A brief description of each pathway is provided and includes a rationale for how the proposed mechanism (italics) operates.

Pathways contributing to the acceptability of the exercise EBIs

Develop knowledge about exercise via education and training

Sites applied strategies to train and educate stakeholders about exercise and cancer. This increased knowledge addressed a common barrier to implementation — a lack of confidence amongst staff to discuss exercise with patients. Education and training were targeted to develop both procedural and scientific knowledge. For example,

Table 4 Program Sustainability Assessment Tool results at each case site and across sites

Domain	Definition[a]	Case site A Mean[b] (SD)	Case site B	Case site C (youth)	Case site C (adult)	Cross-site scores
Environmental support	Having a supportive internal and external climate for your program	6.1 (0.6)	5.2 (0.6)	5.6 (0.3)	3.8 (2.2)	**5.3 (1.3)**
Funding stability	Establishing a consistent financial base for your program	5.2 (0.3)	3.4 (1.4)	4.9 (1.4)	3.8 (0.9)	**4.3 (1.2)**
Partnerships	Cultivating connections between your program and its stakeholders	5.1 (0.8)	5.2 (1.5)	5.0 (0.6)	2.2 (0.9)	**4.2 (1.5)**
Organizational capacity	Having the internal support and resources needed to effectively manage your program and its activities	4.8 (1.0)	5.4 (0.4)	5.6 (0.6)	3.7 (2.3)	**4.9 (1.2)**
Program evaluation	Assessing your program to inform planning and document results	4.6 (0.9)	6.2 (0.5)	5.4 (0.3)	4.2 (2.2)	**5.0 (1.3)**
Program adaptation	Taking actions that adapt your program to ensure its ongoing effectiveness	5.9 (0.7)	6.3 (0.6)	5.6 (0.3)	5.6 (1.5)	**5.8 (0.8)**
Communications	Strategic communication with stakeholders and the public about your program	5.3 (1.1)	5.7 (1.1)	4.2 (1.3)	3.5 (2.8)	**4.8 (1.6)**
Strategic planning	Using processes that guide your program's direction, goals, and strategies	4.6 (0.7)	5.5 (0.1)	4.9 (0.8)	3.2 (2.6)	**4.6 (1.4)**
Sustainability score		**5.2 (0.7)**	**5.4 (0.4)**	**5.2 (0.3)**	**3.7 (1.7)**	

The bold is used to indicate the total for each section in the table

[a]Definitions as supplied

[b]Possible range; 1–7, with higher scores indicating areas of greater program strength

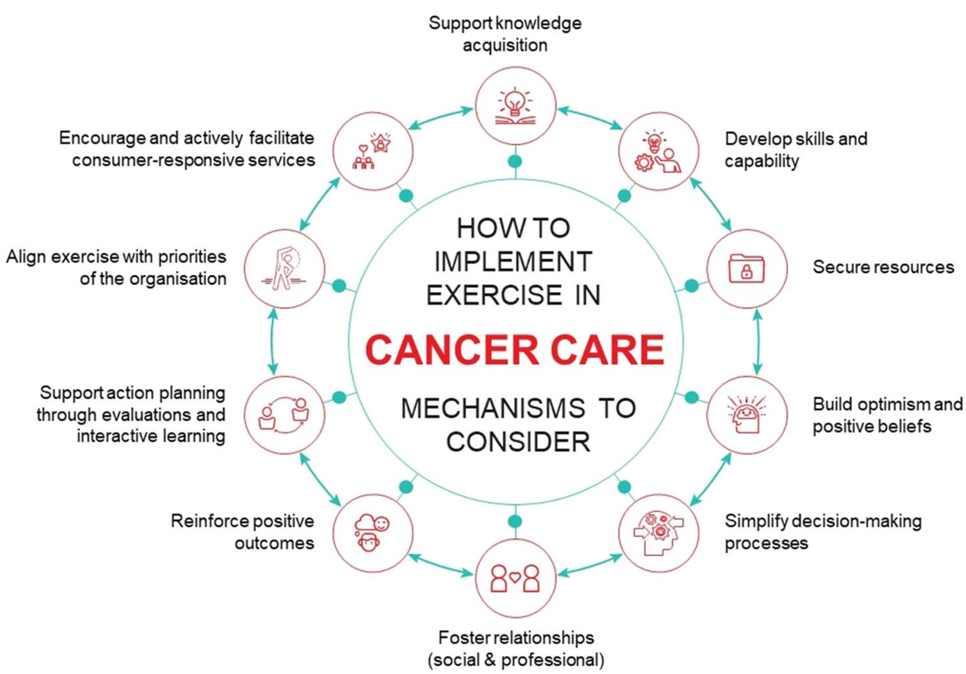

Fig. 1 A summary of exercise implementation in cancer care

hosting multi-disciplinary team meetings where program updates could be shared (procedural knowledge) and access to ongoing training so delivery staff maintained currency of knowledge (scientific knowledge).

Foster social and professional identity by developing relationships across the healthcare workforce

Strategies, including network weaving, were used to leverage social connections and develop professional role expectations and identity. These actions sought to augment the organisational dynamics and increase the strength and quality of networks and communication between healthcare providers. We hypothesise this motivated staff to align their behaviour with the expected functions of their role. Further, the qualitative data points suggested staff became more responsive to other clinicians' needs through strengthened relationships.

> "There is a lot of communication and that is a big strength of (site name), we have always been like a big family here. I sit in the same room as other oncologists and they can see the work I am doing and the meetings I am having with members of the team." (Int-4)

Develop stakeholders' skills and capability by adapting exercise EBIs to the changing context

Promoting the adaptability of EBI components developed stakeholders' skills and capability in exercise. For patients, the type, dosage, and how exercise was delivered were all considered for adaption. The primary modification made for healthcare workers was to change referral methods. Adaptations increased skills and capability by facilitating mastery of the desired behaviour (i.e., patients can complete the prescribed exercise and healthcare workers make referrals to the service).

Build optimism and positive belief about the EBI by engaging stakeholders

Optimism about exercise EBIs was built through increasing the demand for the service. This was typically achieved by champions developing consumer activists who would advocate for the service. This resulted in changing stakeholders' beliefs that motivated them to support the exercise EBI because it was perceived as the "right" option.

> "I think the executive were very surprised that we had 700 signatures… so to see the amount of support we had." (Int-3)

Acceptability was described differently across sites, which could be attributed to the degree to which differing implementation strategies were applied. For example, sites that invested more time in creating high-quality networks (or connections) experience higher levels of acceptability [55]. By contrast, organisational acceptance was low when the exercise EBI operated in isolation, as shown in the quote below:

> "I guess that's kind of hard to tell…. so I think those that are directly involved with it think it's well received. But in terms of the wider scope, of outside of the department, I don't really know." (Int-13)

Pathway contributing to the fidelity of the exercise EBIs

Individuals engage in informal action planning via the provision of supportive, interactive assistance

Learning climate was a prioritised determinant across sites. Sites leveraged this climate by providing interactive assistance to ensure the quality of exercise EBIs. We theorise that the reciprocal nature of strategies such as facilitation and technical assistance encouraged an informal action planning method (i.e., changes in behaviour based on data). Protected time for problem-solving clinical and implementation issues existed across all sites.

Establish methods for ongoing evaluation and iteration that encourage change based on data

All sites tracked implementation via evaluation strategies, such as establishing quality monitoring systems or purposely re-examining implementation. Healthcare providers identified relevant measures of care, such as patient-reported outcomes or referral numbers, to monitor the service. The strategies encouraged planned changes to the service (action planning) based on acquiring targeted knowledge.

> "We do track the effectiveness of what we're doing. So for example, if we get ten new inquiries each week and I only answer five of them, then obviously that's a bit of an issue. At the end of every week, I'm tracking how many new inquiries we had. How many of those people have transitioned to being clients? And if they've declined –why? Is it too expensive? Do they live too far away? So trying to capture the reasons why people aren't taking part and then we can use that data to address things." (Int-6)

Arguably, the effectiveness of these strategies was enabled by the provision of resources that supported implementing with fidelity [56]. This included the provision of standardised training and templates to guide practice. Staff also had the autonomy to adapt and change procedures/processes based on the findings of ongoing learning.

Pathways contributing to the penetration of exercise EBIs

Reinforce the expected outcomes of the EBI by supporting healthcare workers

A strategy applied across sites to support healthcare workers was relaying clinical data reinforcing the desired clinical behaviour. That is, for healthcare workers to act and make referrals to the exercise EBI. This strategy created a positive feedback loop because workers were exposed to the outcome of their actions which motivated the likely repetition of that behaviour in the future [57, 58].

Simplify decision-making processes associated with the EBI by creating the perception of a one-stop-shop

Easy access to information facilitated implementation across sites and was enabled by strategies that created the perception of a one-stop shop. Actions such as creating new clinical teams transformed exercise from an isolated intervention to a comprehensive program. This reduced the need for stakeholders to remember critical information about the exercise EBI and simplified the decision-making process by decreasing the cognitive load. In some cases, this extended to removing decision-making altogether through "opt-out" referral practices, as suggested in the quote below:

> "So, the success of our programme has really been taking a much more macro approach to exercise, and embedding that within the core delivery of our program… (by contrast) if you have an add-on service then it's very, very hard for us to know who to refer to, and which patients we select to get it" (Int-15)

Create an aligned goal between the EBI and the organisation by capturing information that supports executive priorities

Organisations employed implementation strategies, such as involving executive boards that operated to align exercise EBIs with the priority goals of the organisation. That is, staffs were aware of the policy and funding levers within the outer setting and elevated the pulling effect of these determinants through to leaders [59]. They achieved this by ensuring leaders were provided with relevant information on the exercise EBI that aligned and contributed to organisational goals. For example, one report stated: "The governance of (site name) and its deliverables to both the (health department) and the Commonwealth Government remains the responsibility of (site name)…. On behalf of the (site name), we are pleased to submit our progress report to the (health department) which builds on the previous six month report" (DR–125)

These pathways supported both service-level (seven and eight) and sub-system level (nine) penetration. Service level penetration varied across sites (from low (17.2%) to high (80.6%)), which may be attributed to the scope of strategies taken to simplify decision-making (i.e., "opt-out" processes within the "one-stop-shop"). "Opt-out" referral meant penetration was not reliant on individual clinician behaviour (i.e., healthcare professionals discussing exercise with patients and then deciding (and acting) to make a referral).

Pathways contributing to the sustainability of exercise EBIs

Grow and secure resources by accessing new funding and developing resourcing-sharing agreements

Available resources were a consistent barrier identified across sites. Organisations addressed this barrier by pursuing strategies, such as accessing new funding or creating resource-sharing agreements, which secured increased resources and provided more opportunities for the exercise EBI. Once extra resources were secured staff would work to hold the change and prevent the organisation from reverting back to the status quo.

> "But we've grown (exercise) over time and been able to maintain that ring-fence. Because there's been questions over time, should we convert it to physio,… we've been very mindful of the risk that it will be lost amongst all the other priorities." (Int-16)

Drive consumer-responsive decision-making through leveraging interpersonal relationships coupled with action planning

Organisations implemented strategies, such as establishing consumer advisory committees that embedded patient needs within the service. These strategies brought together different stakeholder groups and created social change by influencing interpersonal relationships. Typically, opportunities to improve the service were pursued from these interactions or information gathered from consumers.

Securing resources and driving a consumer-responsive service are suggested to contribute to sustainability. However, we note that the actions described through preceding pathways (i.e., actions to increase acceptability, fidelity and penetration) also contributed to sustainability outcomes. To illustrate, skills and capability in exercise were developed through promoting adaptability, which contributed to acceptability. Program adaption was also identified as a strength contributing to sustainability (via the PSAT). Similarly, we hypothesised that evaluation strategies were necessary for enabling change based on data, contributing to implementation fidelity. Program evaluation was also a strength identified through the PSAT. Finally, the site that achieved high penetration levels spoke about an evolving service model consistent with our sustainability measures (i.e., evolution over time). Staff recognised the priorities of service users, and the organisation changed, and their model needed to change to remain relevant and acceptable to stakeholders, as shown in the quote below:

> "So as our services evolve, we've evolved that model. And we piloted and tried some stuff, and then that hasn't worked and we shifted on to other areas….so it's a model that is kind of continuously evolving." (Int-14)

Figure 2 combines these pathways within an implementation logic model to explain the implementation process of exercise EBIs in routine cancer care. The logic model groups each pathway according to its immediate implementation outcome. However, multiple arrows are added to the logic model to demonstrate the interrelationships between constructs and outcomes.

Discussion

This is one of the first studies on exercise EBIs and cancer that systematically identifies determinants, implementation strategies and outcomes. Further, via multiple case study methodology, the program logic and relevant theoretical application, 11 causal pathways explaining the implementation process are proposed. These pathways represent potentially transferable elements that can be drawn upon to support future implementation efforts in exercise and cancer. In the following section, we discuss some of the key findings.

Our first study aim was to identify commonalities and differences in determinants, strategies, and outcomes. We commenced by considering each construct separately, viewed through the lens of the relevant framework, and consequently undertook a process to make sense of and unify these constructs through the IRLM [60, 61]. Davidoff (2019) describes this process as a mechanic needing to understand the different parts of a car before the vehicle can be repaired [60].

Consistent with other studies in exercise EBIs and cancer, multiple determinants that influence implementation were identified across all levels of implementation. Building on the existing knowledge in exercise EBIs and cancer we identified 11 determinants that, across different contexts and healthcare settings, were highly influential within the implementation process. While studies in exercise and

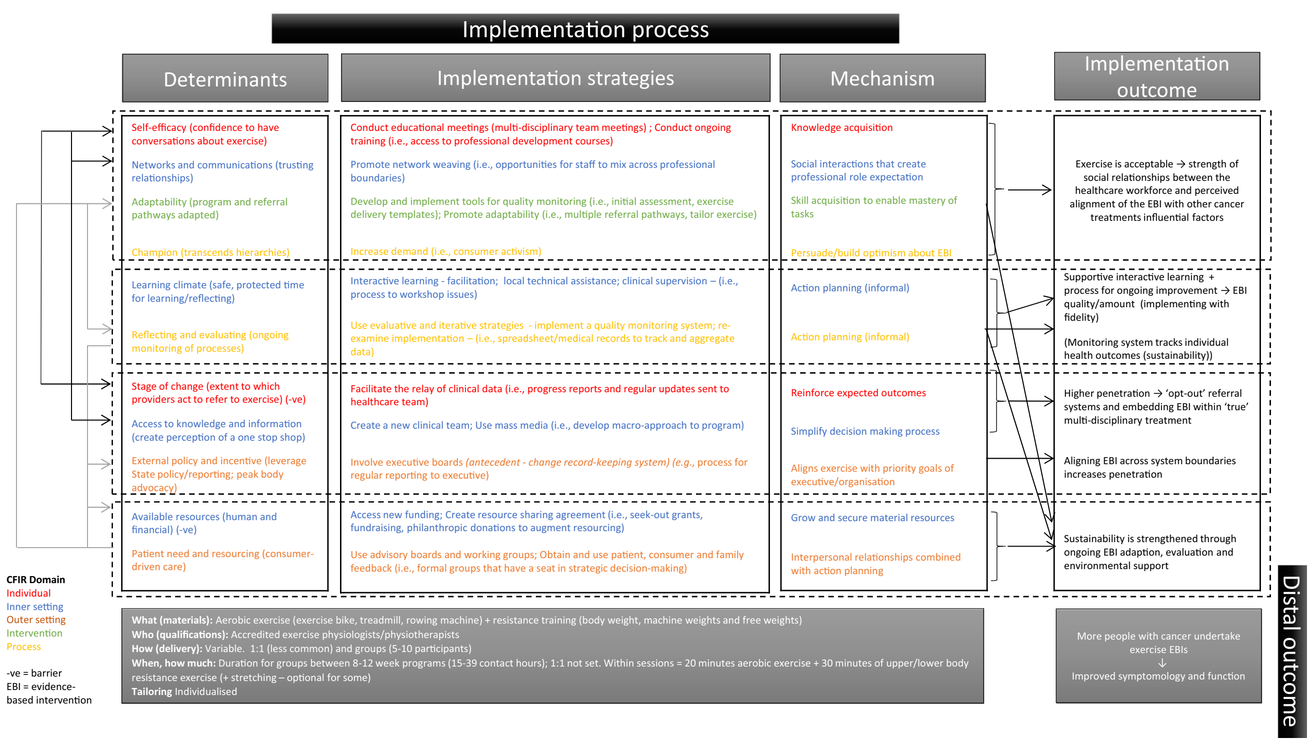

Fig. 2 Implementation logic model for exercise evidence-based intervention in cancer care

cancer have applied the CFIR to guide study elements [32, 62–64], prioritising determinants is less common, despite being a way to identify those factors more likely to inform implementation success [65, 66]. Consistent with our findings, previous studies in exercise and cancer that have prioritised the determinants as most important for implementation success have identified: patient need and resourcing [31, 67, 68], available resources [67, 68], adaptability [31], reflecting and evaluating [31], and external policies and incentives [68]. More broadly, implementation scientists have identified patient need and resourcing (relative advantage and tension for change), as factors associated with implementation success across multiple studies [66] and available resources as a highly prominent determinant [69]. Our findings can be applied prospectively to focus attention in needs assessments that plan to implement exercise in cancer care. Prioritising determinants can help with selecting and matching implementation strategies.

Across sites over 30 implementation strategies were used to support implementation, with 22 strategies common in all sites. This figure is consistent with other implementation research that suggests organisations typically employ numerous strategies [70–73]. To our knowledge, of studies that use the ERIC taxonomy to document implementation strategies in exercise EBI and cancer, many report fewer than ten strategies [42, 74], with only one other study conducting comprehensive mapping [34]. Our process to identify strategies and then apply an inductive approach to develop the explanatory pathways helps address the identified gap between the number of strategies prospectively included in implementation trials and the actual number used when retrospectively identified [75]. We identified several plausible strategies within the individual pathways that can now be applied prospectively. Several methods have been trialled to support pragmatic documentation of implementation strategies in research and practice [70, 73, 76, 77]. It is also feasible for non-specialists to accurately identify strategies when supplied with a standardised list [78]. Future studies can build on our work to develop a knowledge bank of implementation strategies most helpful for integrating exercise into cancer care. This may also include concurrent reporting of implementation strategies in clinical trials and conducting hybrid effectiveness-implementation trials that provide crucial information about how to implement, alongside understanding the clinical impacts of the EBI [76, 79].

The third area where we sought to identify commonalities and differences across sites was by evaluating implementation outcomes. Evaluations of implementation outcomes help to define implementation success. However, it could be argued that some of the exercise EBIs we evaluated had limited success, noting some sites exhibited low penetration rates, low PSAT scores, and differing levels of acceptability. It is probable that implementation outcomes need not be compartmentalised as successfully achieved or not but viewed as to what extent the outcome has been achieved [80]. Staff continually flexed and evolved in response to their environment and made changes to the EBI in response to an implementation outcome. To illustrate, delivery staff often changed EBI components and made decisions during a consultation about the most critical element to deliver on that day, which likely impacts implementation fidelity. Staff would also self-organise to pursue new funding opportunities as they arose, potentially influencing perceptions of sustainability. By contrast, in response to low penetration outcomes, staff changed the service delivery model to better integrate exercise EBIs into existing clinical workflows.

Notwithstanding the fluidity of implementation outcomes two key findings are highlighted from our work. First, consistent with an update to the CFIR [81], we identified a relationship between acceptability and other outcomes, suggesting acceptability is an antecedent that may predict actual implementation outcomes. The site where staff reported lower awareness of the exercise EBI also achieved low penetration (service level) and the lowest scores on the PSAT (sustainability). These findings confer with recommendations to measure acceptability early in the implementation process to understand whether the organisational conditions are suitable for implementation [20, 82]. Second, creating an "opt-out" referral system was associated with higher penetration. This is consistent with findings that indicate creating default options that direct healthcare providers down a path of least resistance increases referrals (in cardiac rehabilitation) [83, 84]. In our study, sites developed an "opt-out" system when clear eligibility criteria were established for EBIs and resourcing matched the anticipated demand for the service. There is a need to consider how "opt-out" referral systems may operate in exercise and cancer to increase penetration. Kennedy and colleagues have recently described their efforts to create an "opt-out" system in exercise and cancer by developing an integrated workflow, which resulted in a three-fold increase in program reach [85]. This could work in tandem with recent work to develop exercise oncology clinical pathways and decision-support tools to increase the uptake of exercise EBIs in cancer care [8, 86, 87].

The second main aim of this study was to develop an explanatory causal pathway for how implementation occurred. This work provides important insights into the transferable elements that can be applied in future implementation efforts. Critically, these pathways exhibit interrelatedness, rather than being isolated, linear, cause-and-effect processes. Recognising this complexity and identifying the function or mechanism theorised to produce change can provide guidance when considering the transferability of findings. This encourages reflection about how strategies lead to behaviour change rather than just identifying what the strategy is [57]. To illustrate, based on findings from our case studies, a range of evaluation and iterative implementation strategies were applied. However, we suggest the mechanism of change was a form of action planning. Similarly, training and education opportunities varied; however, the mechanism was to increase knowledge. The practical implications of these findings are that multiple strategies might be suitable to perform a function, however, drawing together a bundle based on their mechanisms and ability to directly influence determinants may help focus efforts. The disciplines understanding of mechanisms is still in a formative stage, with work underway to identify common strategies/mechanism relationships by some researchers [88, 89]. To our knowledge, only one other study in exercise and cancer has sought to identity mechanisms [42]. Similar to our findings, Kennedy and colleagues identified strategies from across ERIC categories that sought to increase knowledge, secure resourcing (financing) and improve intra-organisational communications. Our approach used relevant frameworks and multiple case study methods coupled with program logic to propose mechanisms. This may be considered an early stage of developing transferable elements [90]. These relationships require empirical testing, with refinement expected from those outcomes. These pathways provide direction on the suite of actions needed to support successful implementation in exercise and cancer. They provide a starting point for conversations and planning between stakeholders seeking to implement exercise EBIs in cancer care.

Limitations

This study used a novel and comprehensive approach to develop a synthesised logic model of the implementation process. Nevertheless, some limitations need to be addressed. Lewis and colleagues recommend identifying mediators and pre-conditions when developing causal pathways [22]. Sales and colleagues suggest mechanisms of determinants, in addition to mechanisms of implementation strategies, should also be identified when using the IRLM [91]. Further, the IRLM does not specify a framework to explicate mechanisms. Although we considered existing literature, we did not explicitly apply a framework to identify mechanisms. Implementation scientists have suggested this is possible with the ERIC and behaviour change technique (BCT) taxonomy (which underpins the behaviour change wheel (BCW)) [92]. Through secondary analysis of the case study database, it would be possible to deconstruct individual pathways further to identify mechanisms of determinants, moderators and pre-conditions. Additionally, a comparative analysis could be undertaken to match the mechanism with the source of behaviour on the BCW (i.e., capability, opportunity, motivation), however, was outside the scope of this study.

COVID-19 interrupted our planned data collection meaning fewer hours of onsite observations were conducted at one case site. The study also selected participants who had a working knowledge of the exercise EBI to understand their views and experiences. Seeking out a broader range of stakeholders, including those who have no knowledge of the service may elicit useful insights. There is also a need to test and replicate our approach across more sites given the formative nature of our work in exercise and cancer.

Conclusion

In summary, we identified commonalities in determinants and strategies (including mechanisms) that facilitated the development of potentially transferable explanatory causal pathways for exercise EBIs in cancer care using a multiple case study approach. The pathways we identified were interrelated and dependent upon each other to produce the resulting outcomes. By identifying mechanisms of change, we demonstrate that multiple strategies are needed for successful implementation as they may contribute to change in different ways and lead to different outcomes. Future studies can build on this work by empirically testing various elements of the hypothesised causal pathways and applying our findings prospectively to develop implementation plans. This is one of the first studies in exercise and cancer that, across multiple sites, systematically applies and then combines multiple implementation science frameworks to explain the "how and why" of implementation. These findings can support efforts to scale exercise EBIs as a standard component of cancer care.

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Author contributions EZ, NR, JR, PC, SR, and LC developed and conceived study design. EZ, PC, JT, AM, and LC conducted data collection. LC lead data analytics with support from EZ, NR, JR, SR, and LC wrote the main manuscript text. All authors reviewed the manuscript and provided critical analysis prior to completion.

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Data availability The data that support the findings of this study are available on request from the corresponding author [LC]. The data are not publicly available due to containing information that could compromise research participant privacy.

Declarations

Ethics approval This study is approved by Sydney Local Health District Human Research Ethics Committee - Concord Repatriation General Hospital (2019/ETH11806). Ethical approval is also supplied by Australian Catholic University (2018-279E), Peter MacCallum Cancer Centre (19/175), North Sydney Local Health District - Macquarie Hospital (2019/STE14595), and Alfred Health (516-19). This project was carried out according to the *National Statement on Ethical Conduct in Human Research (2007) (Updated 2018)*. The National Health and Medical Research Council, the Australian Research Council and Universities Australia.

Consent to participate Freely given, informed consent was obtained from all individual participants included in the study.

Competing interests PC is the Founder and Director of EX-MED Cancer Ltd, a not-for-profit organisation that provides exercise medicine services to people with cancer. PC is the Director of Exercise Oncology EDU Pty Ltd, a company that provides fee for service training courses to upskill exercise professionals in delivering exercise to people with cancer.

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7.3 Concluding statements - Section 3 (Chapters 5, 6 and 7)

Section 3 of this thesis addressed the second sub-aim of this thesis by demonstrating how mental healthcare and cancer care organisations have successfully implemented exercise EBIs.

A thorough description and rationale, via systematically linking implementation science frameworks and applying relevant program logic and case study methods, provided the foundations for exploring and explaining the implementation process at different healthcare sites. Through this process, a complex mix of determinants, implementation strategies and outcomes of implementation efforts were uncovered. The IRLM's that were applied to map and interpret the findings helped make sense of the voluminous data. Through re-working the IRLM the explanation for implementation was produced.

At each site, different factors influenced implementation and different strategies were used, contributing to different outcomes. However, the multiple case study in cancer described in Chapter 7 helped elucidate commonality across sites that can inform future implementation efforts.

In the next section the body of work produced through this thesis is discussed. This includes the overall strengths and limitations of the work, the contribution to the literature and the practical application of the findings to facilitate implementation practice.

iv 8.0 CHAPTER EIGHT: Thesis discussion and conclusions

This thesis sought to understand how exercise EBIs are integrated into routine practice to treat NCDs. Two sub-aims inform the response to the primary research aim: 1) conduct novel evidence synthesis of exercise EBIs for mental illness and cancer to understand how different synthesis methods can support improved implementation in practice; and 2) explore how healthcare organisations have successfully implemented exercise EBIs within routine practice for treating mental illness and cancer. This chapter contains a summary of the main findings of the thesis. The significance of these findings and future research directions are discussed with reference to the four research gaps identified in Chapter 1. The chapter concludes by highlighting the practical application, strengths and limitations of the body of work comprising this thesis.

8.1 Overview of findings

In Section 1 (chapters 1 and 2) the evidence for exercise as a treatment for NCDs was established (1, 2). Regular exercise can positively impact almost every bodily system (3). It can improve cardiac function, metabolic control, cognition, memory, digestive function and musculoskeletal health. Within these broad-based benefits, researchers are advancing their understanding of the clinical impacts of exercise on specific NCDs, including mental illness and cancer. In sections 2 and 3 of this thesis, these conditions were the subject of investigation because workforce projections identify these conditions as growth areas for healthcare workers skilled in exercise prescription (4, 5). Further, both conditions are significant contributors to disease burden, with exercise providing a strategy to potentially ameliorate disease burden impacts (6, 7). The culminating evidence base in mental illness and cancer has resulted in multiple calls to action to embed exercise in standard care (8-11). However, the potential value of exercise EBIs will only be realised if the research-to-practice gap is addressed.

The research-to-practice gap is a complex and multi-faceted issue. It commences with existing practices for how research evidence is conceived, funded, produced and then considered for application in practice. Historically, the integration of evidence into practice was an afterthought of the research process or assumed to occur automatically. This is not the case, with the field of implementation science recognising that active methods are needed to move evidence into practice. Only interventions with a supporting research evidence base should be considered for implementation. However, existing methods for synthesising the research evidence rarely consider its practical application and can, in fact, add to the research-to-practice gap. Hence, the first step of this thesis was to investigate the evidence base for mental illness and cancer with a focus on outcomes that are relevant for implementation and that generate evidence that is useful for practice.

8.1.1 Conduct novel evidence synthesis of exercise EBIs for mental illness and cancer to understand how different synthesis methods can support improved implementation in practice

Section 2 of this thesis included two chapters that address the first sub-aim of this thesis. Evidence is foundational to implementation science because the overall purpose of the field is to increase the use of EBIs, the premise being that scientific research has concluded that an EBI elicits sufficient benefit to individuals and communities that its widespread use is warranted (12, 13). However, academic communities recognise that the historical research methods used to establish the evidence base are flawed when seeking to inform practice (14-16). This may inadvertently contribute to the poor uptake of research, which contributes to the research-to-practice gap (17). Clinically useful research is said to include pragmatic research designs, including innovative evidence synthesis methods, and establishing real-world acceptability and feasibility of an EBI. Further, measuring outcomes that are important to patients and ensuring an EBI represents good value for money is also recommended (14-16).

In Chapter 3, a meta-review design was used to synthesise the evidence for exercise EBIs and mental illness to determine effectiveness. Effectiveness was defined in clinically useful terms including the anticipated health benefits, safety and whether the EBI represents good value for money. The review summarised the effectiveness of exercise across six different mental health conditions (i.e., depression, schizophrenia, anxiety, posttraumatic stress disorder, substance/alcohol use and multiple diagnoses). Most reviews were identified in depression (8 reviews) and schizophrenia (8 reviews), with fewer reviews summarising the effectiveness of exercise in the treatment of posttraumatic stress disorder (1 review). The meta-review revealed that across various conditions and different types of exercise (i.e., yoga, football and structured exercise), most reviews (32 of 33 included studies) reported positive outcomes supporting the effectiveness of exercise EBIs. According to our definition of effectiveness, most reviews measured the clinical impact of exercise on the symptoms of mental illness. Reporting on adverse events was less common, and no studies that included cost data were found.

In Chapter 4, the second novel evidence synthesis method was applied. It was a systematic review exploring implementation outcomes of exercise EBIs in cancer care. To our knowledge, it is one of the first studies on exercise and cancer involving the synthesis of implementation outcomes with Proctor and colleagues' IOF. By excluding efficacy studies and summarising implementation outcomes in real-world practice, the practical application of our findings may be enhanced. This is because the myriad of contextual factors that influence evidence use and decision-making are elucidated (18). This encourages researchers and practitioners to start working with complexity rather than seeking to control it, as is the case in efficacy studies (19). Successful implementation is often defined and measured via implementation outcomes (20), which is also important for avoiding the conflation of EBI success and implementation success (21), for example, by concluding that an EBI is ineffective in practice when actually an implementation failure has contributed to the poor outcome (22, 23).

The review explored all eight implementation outcomes described in the IOF. Most exercise interventions were group-based and delivered in a community setting by qualified health professionals to people with a range of cancer diagnoses. Most studies were classified as effectiveness studies, and the most common implementation outcomes reviewed were feasibility and adoption. By contrast, the least common implementation outcomes evaluated were penetration and sustainability, and implementation fidelity was difficult to ascertain. Taken together, the review revealed that exercise EBIs are being successfully implemented in practice. However, we need additional information on how success is defined, measured and reported.

To conclude, Section 2 of this thesis included two approaches to systematic reviews designed to elicit information that is helpful for implementation practice. The reviews generated insights that can better inform practice compared to traditional synthesis methods. However, noting the gaps identified through these reviews, much scope exists to augment existing methods of research production and synthesis to help develop an evidence base that better supports translational efforts. In the next section, the contributions this thesis makes to addressing some of these gaps through the implementation research studies that were completed, are discussed.

8.1.2 Explore how healthcare organisations have successfully implemented exercise EBIs within routine practice for treating cancer and mental illness

Section 3 of this thesis comprised three studies and sought to address the second sub-aim of this thesis.

Chapter 5 provided a detailed description and rationale for case study methods and how a theoretically driven approach can help explore the implementation process. Specifically, the chapter detailed how case study methods were applied to develop an IRLM. As the IRLM is a relatively new tool for explicating the program logic within the implementation process, it was necessary to detail our approach. The tool encouraged the use of a comprehensive approach, and the complete identification and documentation of determinants and implementation strategies were achieved. Critical study design elements for how implementation outcomes were measured were also documented. Second, the IRLM calls for key conceptual relationships to be identified. Although this was possible via the use of colours in the IRLM, it was challenging to reconcile the innately linear approach to implementation that the IRLM elicits versus the interactive and dynamic nature of implementation in practice. We sought to resolve this issue by redeveloping the IRLM within a more traditional logic model structure that added several uni- and bi-directional arrows to demonstrate the interrelatedness of constructs.

The second main aim of the study described in Chapter 5 was to uncover whether synthesis across different settings was possible with the IRLM. This was an area in which the utility of the IRLM was underexplored (24). Through the study, it was possible to synthesise findings across sites using a multiple case study design. By comparing and contrasting results across sites, commonalities and differences were uncovered that facilitated the synthesis. The ability to synthesise findings across sites strengthens the generalisability of findings.

Chapter 6 provided the findings of the first of two studies in which the case study methods described in Chapter 5 were applied. The first study was a case study on the implementation of exercise EBIs in a community-based youth mental healthcare service. The study identified 43 unique determinants that influenced implementation. A similar number of implementation strategies was identified, and several service gaps were identified by evaluating implementation outcomes. These gaps included a lack of process for measuring the ongoing sustainability of health outcomes, no method for measuring the fidelity of implementation as aligned to the dose/amount needed to produce clinical outcomes and a potential referral bias whereby only youth with the most acute needs were referred to the exercise service. The simplified IRLM and re-produced logic model identify some similarities between the proposed mechanism of change in this study and those in existing studies. This included the use of manager feedback to motivate staff, delegating task responsibility to a specific person, building trusting relationships among staff and augmenting clinical norms.

Several critical implementation barriers and strategies were highlighted in this study. This included staff's lack of capability and experience with the exercise EBIs, the perception that screening and referral for exercise was more work and the relative priority of exercise was low when dealing with crisis issues (i.e., homelessness). Leaders undertook several actions to support the workforce, including allocating direct and additional resources for the service, providing protected learning time and prioritising a safe organisational climate. The leaders' actions to c*reate a new clinical team* by hiring a staff member with overall responsibility for physical healthcare, including exercise, was critical to implementation of exercise EBIs. This is because they implemented an *audit and feedback* system that increased healthcare providers' compliance with existing organisational procedures pertaining to assessing physical healthcare and referral to exercise.

The final study comprising this thesis is described in Chapter 7. It was a multiple case study in which we examined the implementation of exercise EBIs in cancer care. In the study, we sought to identify commonalities and differences across three case sites. From there, an explanatory causal pathway for implementation was developed. Across sites that implemented different exercise EBIs, 18 determinants and 22 implementation strategies were consistent. By contrast, 16 determinants and 24 implementation strategies differed. Implementation outcomes also varied. However, commonalities in factors contributing to sustaining exercise EBIs were identified via the PSAT. These factors included program adaption and environment support, wherein the constructs of environment support included the support of a champion, leadership and the public. The study culminated in the development of 11 pathways that explained the implementation process when combined. They also offer transferable findings that can form the basis of future implementation research in exercise EBIs and cancer. These pathways included (mechanism *italicised*): 1) developing *knowledge* about exercise via education and training; 2) fostering *social and professional identity* by developing relationships across the healthcare workforce; 3) developing stakeholders' *skills and capability* by adapting exercise EBIs to the changing context; 4) building *optimism and positive beliefs* about the EBI by engaging stakeholders; 5) individuals engaging in informal *action planning* via the provision of supportive, interactive assistance; 6) establishing methods for ongoing evaluation and iteration that encourage *change based on data; 7) reinforcing* the expected outcomes of the EBI by supporting the healthcare workforce; 8) *simplifying the decision-making processes* associated with the EBI by creating the perception of a one-stop-shop; 9) creating aligned *goals* between the EBI and the organisation by capturing information that supports executive priorities; 10) growing and securing *resources* by accessing new funding and developing resourcing-sharing agreements; and 11) driving consumer-responsive decision-making by leveraging *interpersonal relationships* coupled with *action planning.*

In conclusion, Section 3 of this thesis includes the methodological approach and findings of two studies in which we explored the implementation of exercise EBIs in mental illness and cancer care. In these studies, we applied many of the core constructs of implementation science. Appropriate theoretical application coupled with program logic was used to elucidate the implementation process. Implementation research exists in a relatively formative state concerning both mental illness and cancer care, where exercise is the EBI of interest. As such, there is much scope to build on the work presented in this thesis. The precise application of fundamental implementation science constructs and principles provides a solid foundation for further research. In the next section, we discuss the significance of the findings, areas for future research and the practical application of the work.

8.2 Significance of findings, future research directions and practical application

In Chapter 1, four research gaps were identified that this thesis sought to address. These gaps were: 1) applying novel evidence synthesis methods; 2) specifying implementation strategies according to a recognised taxonomy; 3) contributing to understanding the later stages of implementation (sustainability); and 4) innovative theoretical application of implementation science frameworks. The significance of our findings and the opportunity to build on the work presented in this thesis are discussed with reference to these four research gaps.

8.2.1 Applying novel evidence synthesis methods

The first research gap was addressed through the two systematic reviews. The concurrent aim of these reviews was to apply novel methods to improve the practical application of evidence in practice.

The meta-review was the first innovative method. The technique allowed for synthesis of information across several mental health conditions and a broad, implementation-focused definition of effectiveness. Its breadth may help to address the research-to-practice gap by providing an accessible synthesis of the available evidence to support decision-making (25-27). It can also be applied to address conflicting findings in separate systematic reviews, which can be a barrier to evidence uptake (28, 29). Further, the method does not exclude studies through the quality assessment (30). In place, a critical analysis is conducted on the overall body of published works, improving the transparency of the totality of evidence for a given topic (31). This is evidenced in our meta-review in which the conflicting findings in previous systematic reviews about the effectiveness of exercise as a treatment for depression were addressed. At face value, this may reduce the knowledge lost through evidence-synthesis practices. Studies with potentially valuable insights are preserved, despite failing to meet pre-established quality standards, so conflicting evidence can be reconciled.

The review revealed research gaps in cost and safety data. The lack of reporting on adverse events is a recognised issue across many health interventions (32-34), including exercise EBIs for people with mental illness (35, 36). Highlighting these gaps is an important finding of our work to guide the future development of clinically useful research (14-16). It ensures that ensuing work builds on these gaps to avoid duplication, which adds to research waste. Augmenting these data gaps through other methods may also be helpful (34). This may include summarising indirect evidence, which provides information outside a pre-determined study protocol, and examining health system data (37). To illustrate, a recent study by Deenik and colleagues sought to understand the cost of implementing a lifestyle intervention that included exercise in an inpatient facility by retrospectively reviewing routinely collected health system data (38). The authors found that the introduction of the lifestyle EBI did not increase healthcare costs. Similarly, a report commissioned by Exercise & Sports Science Australia, on the cost-effectiveness of AEP services in the Australian healthcare system, indicated that for each case of depression averted through the delivery of exercise by an AEP, the healthcare system saved $10,062 per year in 2015 (39). Finally, a recent systematic review of exercise as therapy for several NCDs (including psychiatric conditions) summarised adverse events and found no increased risk of serious adverse events (i.e., death and hospitalisation), but there was an increased risk of non-serious adverse events (i.e., fatigue and pain). The authors concluded that exercise therapy was a safe intervention, but for people with NCDs, closer monitoring may be required to reduce the risk of non-serious adverse events (33). Adopting a pragmatic approach to establishing the evidence base is valuable when addressing the research-to-practice gap.

By contrast, differing benefits (and challenges) were identified when considering the practical application of the systematic review of implementation outcomes. The significance of the findings is the ability to define and understand successful implementation. Extracting implementation outcomes through evidence synthesis is an essential pursuit because it can also improve the generalisability of findings and the implementability of exercise EBIs (21, 40, 41). Tierney and colleagues suggested that extracting implementation outcomes is also feasible, despite being a relatively new approach (42). Shepherd and colleagues identified several learning from their efforts to measure and define implementation success in practice, including: 1) consulting recognised frameworks to develop measures; 2) determining the unit of analysis that is most beneficial for measurement; 3) mapping the outcome to data sources and timing for collection; and 4) including longitudinal qualitative components to define success (21). The most valuable suggestion for practice is identifying measures that simultaneously guide individual patient care and can be aggregated for organisation-wide quality improvement efforts (43). The other primary benefit of applying a novel synthesis method to inform implementation practice was achieved by excluding efficacy studies. By synthesising real-world findings, the review acknowledges the voltage drop of EBIs as they move through research phases to widespread use (44, 45). Promoting pragmatic clinical trials and implementation research may facilitate the elucidation of the actual effect size of exercise EBIs in real-world settings. It can also encourage increased consideration of the ongoing adaptions and optimisations needed to ensure clinical impacts are maintained in complex and dynamic healthcare settings.

Both these reviews were able to elucidate different information that potentially has a greater translational impact compared to traditional synthesis methods. However, it is likely that these methods alone will not resolve the complexity of producing research evidence useful for implementation. They do not provide a definitive answer to the question of whether exercise EBIs are value for money in mental healthcare or provide a framework for the successful implementation of exercise EBIs in cancer care. No single research study can be the panacea to resolve the myriad of factors, activities and people that exists within the implementation process. Notwithstanding this, the results of our reviews should be a catalyst for additional pragmatic approaches to research. Future researchers can directly build on the work presented in this thesis by: 1) improving the consistent reporting on safety of exercise EBIs for people experiencing mental illness; 2) conducting economic evaluations of EBIs to support the efficiency of healthcare services; 3) increase the pragmatic evaluation of implementation outcomes in cancer care; 4) ensure these evaluations involve measuring implementation outcomes across a range of stakeholder interests and levels of implementation; and 5) expand the breadth and range of evidence synthesis methods conducted in exercise EBIs to improve their utility when planning for implementation at the local level.

8.2.2 Specifying implementation strategies according to a recognised taxonomy

The next significant finding of this thesis was the identification of implementation strategies used in exercise EBIs across cancer and mental illness according to a recognised taxonomy. This enables the replication, critical review of impact, and synthesis of implementation strategies in future studies (46). As with clinical research, the reason for comprehensively documenting strategies is to curate a robust evidence base that directs and guides efficient and effective healthcare practices. Data-driven methods of documenting strategies early, for example within clinical research, will also enable exercise EBI researchers to "handoff strategies as a package with the (EBI)" (46, p5). This may help address critiques about the utility of continued investment in the next/new EBI when efforts to implement it are lacking (47).

The other important finding generated by using a recognised taxonomy was the identification of the mechanisms of change of these strategies. The mechanisms of change identified in our studies were produced with reference to the existing literature (48-50), providing some confidence in the relationships put forward. However, several research groups are working to match strategies with mechanisms of behaviour change (51-54), highlighting the developmental state of mechanistic research in implementation science. Nonetheless, identifying mechanisms improves the transferability of findings and helps in the tailoring of strategies. Through the development of the generalised logic model in the cancer case study, it was not possible to distil the relationship down to a common determinant that linked one strategy to a specific outcome. However, by considering the mechanism of change (e.g., building knowledge), it was possible to work recursively to identify implementation strategies used at case sites that had this mechanism in place. Pursuing a mechanism-based selection of strategies may encourage a targeted, efficient and precise approach to future implementation planning. It focuses attention on the agent of change instead of the strategy itself (55). However, this does not detract from the importance of being able to reference strategies using a common language and definition, as facilitated by ERIC. Without this, any form of generalisation would not be possible.

Methods exist to support the pragmatic tracking and reporting of implementation strategies in research studies (56), including the publication of implementation study reporting guidelines (57, 58). Researchers have employed several actions to pragmatic document strategies in practice, including developing activity logs to name and operationalise implementation strategies (59), standardised templates to support implementation strategy reporting by non-specialists (60), applying reporting guidelines to retrospectively define strategies (61) and coding discussions from healthcare team meetings (62). A simple adaption to the existing clinical work for both exercise EBIs in mental illness and cancer is to include a description of implementation strategies in clinical studies (60, 63). This can work in harmony with effectiveness-implementation hybrid study designs that aim to expedite evidence movement through the research translation pathway (60, 64). The work presented in this thesis contains a reference point and method for tracking strategies that can be replicated. Future researchers can build on this work by detailing strategies in clinical, implementation and hybrid design research studies. Using existing taxonomies to document implementation strategies is important so that consistent language and meaning are developed. For clinical research, this represents a simple addition to existing work that could support early planning and the development of EBIs for implementation (47).

8.2.3 Contributing to understanding the late stages of implementation (sustainability)

Sustainability is an under-studied area of implementation science (65-68). However, in recent years, a comprehensive definition (69) and guidance have been developed (70) to support the appropriate selection of measurement tools based on how sustainability is applied in the research study (sustainability is approached as a process or outcome). Measuring sustainability across the combined constructs of its definitions (i.e., continued program components, adaptions over time, after a time period) and at different levels (i.e., organisation and patient level) is recommended (71-73). This includes the exercise EBIs delivered in healthcare settings (74).

The interventional studies of this thesis contributed to this implementation priority by exploring and measuring sustainability through a multi-construct definition. This included the measurement of the definition constructs across different levels of implementation and via a validated measurement instrument, the PSAT. Through the mental illness case study, program adaption and environmental support achieved the highest results on the PSAT, suggesting that they were strengths that contributed to sustainability. Across cancer sites, program adaption and environmental support also had the highest combined results. By contrast, partnerships and funding stability were identified as weaknesses that potentially impact sustainability. It is a significant finding of this thesis that across different NCDs, healthcare settings and programs, the strengths and weaknesses that influence sustainability were the same when exercise EBIs were implemented.

Other studies that have used the PSAT to understand the sustainment of EBIs (not in exercise EBIs) have also identified environmental support (75-77) and program adaption (78) as being highly important to sustainable outcomes. However, given that no comparable studies exist on exercise EBIs and cancer, and to our knowledge, only one other study examining lifestyle interventions in mental illness has used the PSAT (79), the findings should be considered with care. Limited validated tools for measuring sustainability exist, so these findings may also be reflective of instrument issues (80, 81). Further, the existing research on lifestyle interventions for mental illness modified the PSAT before use and added six additional items to the organisational capacity domain (79). Unfortunately, this renders comparison to our findings difficult.

A separate research agenda exists for sustaining EBIs because rapid advances in knowledge are being made (66-68). This includes the refinement of the ERIC taxonomy for the sustainment of EBIs (82) and the recent creation of new sustainability tools (83, 84). Notwithstanding these developments, our work represents some of the first in both mental illness and cancer that focuses on the later stages of implementation. Given the paucity of research that exists in this area, replication is needed in future research. To build on our studies, future works should objectively measure sustainability, using a multi- construct definition of sustainability. Preferably the measurement is guided by a standardised tool that enables comparison to our findings and can build cumulative knowledge (85, 86). This could include measurement and tracking across multiple time points to understand how changing healthcare environments influence exercise EBI sustainability.

8.2.4 Innovative theoretical application of implementation science frameworks

The final gap addressed through this thesis was to apply and combine appropriate implementation science frameworks across studies to explain the implementation process. The process of identifying mechanism of change and building the related causal pathways through the case studies in this thesis was only possible because of the comprehensive theoretical application practiced across studies. The isolated use of each framework in this thesis provided a piece of the implementation puzzle. However, it was only through unification that the real value of the frameworks was realised (87, 88). The implementation process was brought to life, and the complex relationships and interdependencies between determinants, implementation strategies and implementation outcomes were unravelled. Notwithstanding this value, care should be taken to avoid concluding that the 11 pathways presented in Chapter 7 of this thesis form a static model of change for exercise EBIs in cancer care. A balance needs to be struck between valuing the structure that comes with differing frameworks and combining frameworks, but not losing the subtleness hidden within that structure. It is the shades of grey that encompass the unexpected and unanticipated effects that exist within complex implementation settings, such as healthcare settings.

The value that comes with the structure of the appropriate theoretical application of implementation science frameworks can be best seen through its capacity to support cumulative knowledge across the field (89-91). As the approach adopted in this thesis involved employing relevant frameworks at different stages, generalisations that inform future research efforts can be made. We use the term transferability to describe generalisable elements. At the macro-level, generalisability is achieved via the frameworks that are applicable to any EBI in any setting (i.e., the CFIR, ERIC, IOF and IRLM are applicable to most implementation research). However, the transferability of findings, which is the extent to which primary findings can be applied to a specific future context (92), is relevant to the potential future application of exercise EBIs in healthcare. Some scholars have also suggested that the transferability of findings becomes the *working hypotheses* for the subsequent investigation (93). Reflecting on the methods from our case studies, by including the IRLM to interpret the findings, transferability was achieved by identifying patterns across the dataset that provide the overarching take-away message (94). Future reserachers can build on is the take-away message, which in the case of this thesis, is the 11 causal pathways underpinning the successful implementation of exercise EBIs in cancer care.

To directly build on the work presented in this thesis, empirical testing of the 11 pathways is needed. Further, as additional knowledge is built about strategy/mechanism relationships, it is likely that further refinements of these pathways will occur. There are also mechanisms of determinants that influence which implementation strategy should be selected within the causal pathway. Sales and colleagues alluded to this in their commentary on the IRLM (95). They suggested that implementation researchers need to consider the underlying reasons a determinant exists. Only then can a link to an implementation strategy be established. Implementation research is yet to empirically establish these relationships, which presents an opportunity for future research (96).

This thesis makes a valuable contribution to the literature on mental illness and cancer that seeks to support the integration of exercise EBIs in routine care. It has provided insights into *how and why* implementation in real-world healthcare settings occurs. It also contributes to meeting the research priorities identified in implementation science. In the next section, the practical application of these findings is discussed.

8.2.5 Practical application of thesis findings

An immediate contribution that can be applied to implementation practice is the 11 pathways that were identified as underpinning the successful implementation of exercise EBIs in cancer care. Practitioners, researchers and people seeking to implement exercise can prospectively apply the common findings from the case studies to plan for future implementation efforts. In Table 8.1, a lay summary of sample activities aligned with the 11 pathways is provided. It can form the basis for implementation planning. Acknowledging that retrospective analysis of implementation strategies used in practice suggests it is common for over 20 or more strategies to be applied through implementation, starting with a focus on 11 (which were all in use across our 3 case sites), is thought to be feasible. Implementation scientists have sought to rank the ERIC implementation strategies by their feasibility and importance to help selection and prioritisation (97, 98). Waltz and colleagues identified 31 ERIC strategies that were deemed both feasible and important in healthcare settings (98). Through their work, strategies categorised within *Use evaluative and iterative strategies* (i.e., conduct local needs assessment, purposely re-examining evaluation) were identified as some of the most feasible and highly important. These strategies are consistent with activities listed in pathways 6 and 11 in Table 8.1. By contrast, some of the least feasible and least important strategies were categorised within *Change infrastructure* (i.e., change liability laws, change credentialing and/or licensure standards). One strategy (change record keeping) was identified from the *Change infrastructure* categorisation in our pathways. Changing record keeping was typically operationalised as including exercise in an organisation's electronic medical records. Implementing exercise in electronic medical records for cancer care has previously been considered valuable, albeit highly complex (99). As such, in the practical application outlined in Table 8.1, we recognised that this could commence more simply by using a spreadsheet-based system to capture consistent records. Taken together, one might argue that when using the 11 common pathways to commence planning for implementation, retaining strategies within the *Use evaluation and iterative strategies* category might be the highest priority. However, more realistically these activities are anticipated to be a starting point for conversations between communities and stakeholders who are working together on shared implementation projects. Stakeholders will collaborate to determine what is most feasible and important in their unique implementation setting.

Table 1: Prospective plan for implementing exercise EBIs in cancer care: A summary for implementation practice

The common pathways identified through research studies	**Example of prospective application in practice**
1) Develop knowledge about exercise via education and training	1. Provide training to delivery staff to ensure they have expertise in exercise prescription. 2. Ensure delivery staff also have expertise in the NCD that the exercise EBI is intended to address. This includes general presentations/experiences associated with the condition and specific exercise considerations.
2) Foster social and professional identity by developing relationships across the healthcare workforce	1. Establish a community of practice (CoP) for healthcare workers to meet during work hours. 2. To build buy-in across the workforce for the CoP, focus on topics of broad interest (e.g., lifestyle risk factors that include healthy eating, physical activity, and smoking) instead of just exercise. 3. Establish a method whereby the ideas and service improvements generated through the CoP are relayed across the organisation. Change across the organisation should be enacted based on these ideas. 4. Ideally, organisational leaders actively support (or mandate) representation from all teams or professional groups at the CoP.
3) Develop stakeholders' skills and capability by adapting exercise EBIs to the changing context	1. For patients, individualise exercise EBIs and encourage participation in activities that interest them and that they choose.

	2. For referral sources, identify their preferred referral method and ensure this pathway exists. Ideally, offer multiple, straightforward ways to refer (i.e., email, forms and web referrals).
4) Build optimism and positive beliefs about the exercise EBI by engaging stakeholders	1. With help from a champion, identify patients, friends and family members who are passionate, willing and committed to advocating for the exercise EBI. 2. Once these people are identified, work with them to identify deficits and areas of improvement for the program or opportunities to promote its value. 3. This may include advocating for new equipment, attending public events to discuss their experience with the program or supporting and leading fundraising efforts.
5) Individuals engage in informal action planning via the provision of supportive, interactive assistance	1. Establish a mentoring system for healthcare workers (i.e., delivery staff), where specific technical issues (i.e., complex patient presentation) pertaining to the exercise EBI can be discussed and resolved. 2. Although the CoP might operate at a strategic level, the purpose of learning for mentoring is different as it provides direct support for staff delivering the exercise EBI.
6) Establish methods for ongoing evaluation and iteration that encourage change based on data	1. If available, then use electronic medical records (or if not, then use electronic data capture software or a spreadsheet) to capture outcome measures and aggregate these periodically to review exercise EBI performance. 2. At a minimum, outcome measures should include the measures identified in pathways 7 and 9. Further, track referrals from clinicians aligned to pathways 3 and 8. 3. Adapt and refine exercise EBIs based on findings and relay findings to the executive.
7) Reinforce the expected outcomes of the EBI by supporting the healthcare workforce	1. Identify the health and wellbeing outcomes that are important to patients and referral sources. 2. Measure these outcomes through initial assessment forms and then regularly re-assess them as the patient participates in the exercise EBI. 3. Establish a process where progress against these outcomes is regularly relayed to the referral source and patient (e.g., email updates and progress reports).
8) Simplify decision-making processes associated with the exercise EBI by creating the	1. Identify and remove decision-making points associated with the exercise EBI where possible. Seek to create a one-stop shop for the exercise EBI. This could include creating ‘opt-out’ referral processes for the exercise EBI.

perception of a one-stop-shop	2. If the organisation offers other lifestyle services (such as a dietitian or psychology services), then link these services together as a multi-disciplinary program instead of stand-alone exercise services.
9) Create aligned goals between the exercise EBI and the organisation by capturing information that supports executive priorities	1. Identify the organisation's key performance indicators (KPIs) and reporting requirements to funding/policy bodies. 2. Ensure the exercise EBI captures this information and provides it to the executive on a regular basis so the program contributes to meeting organisation-wide priorities and obligations (e.g., through pathways 6 and 7).
10) Grow and secure resources by accessing new funding and developing resource-sharing agreements	1. Approach and establish agreements with local community organisations to facilitate access to their exercise services. This may include reduced-cost memberships for patients, sharing physical equipment or providing access to different types of exercise not offered by the organisation. 2. Include in a job description the requirement for a staff member to seek philanthropic support for the exercise EBI, identify and apply for grant opportunities, create fundraising opportunities, and establish relationships with organisations that can build capacity (e.g., university for student placements).
11) Drive consumer-responsive decision-making through leveraging interpersonal relationships coupled with action planning	1. Establish a consumer advisory committee comprising patients, a range of healthcare workers (i.e., delivery staff and referral sources) and executives. 2. Ideally, the consumer advisory group can provide feedback to ensure the exercise EBI is responsive to patient needs at the direct service level and guide the future strategic direction of the service.

Providing a summary and suggestions for practice is an essential final step to ensure the findings from implementation research are helpful for implementation practice. Implementation science is approaching a critical junction, presenting many worries (100-104). This concern stems from implementation science potentially adding to the research-to-practice gap instead of resolving it. Specialisation is occurring in implementation science, and with specialisation comes siloing within the discipline (101). Although specialisation is important for advancing the depth of knowledge, it can detract from the overall goal of advancing implementation practice when constructs are studied in isolation. Implementation strategy research is advancing to identify the minimum *dose* required to produce an implementation outcome (105). However, identifying the dose without context may replicate the issues of efficacy studies. It may elucidate the optimal strategy but fail to impact practice. Implementation science is also applied across many different research areas, meaning research groups can explore the same topic without benefiting from shared knowledge or expertise (47). This potentially adds to the research waste that implementation science seeks to reduce.

Next, the discipline acknowledges that historically it has lacked a focus on equity. This means that any advances produced through the field will likely benefit society's *best off*, and not the people who need it most (47, 103, 106). Healthcare is riddled with examples of systemic inequality, and without due attention, implementation science may widen disparities (106). Equity-focused implementation frameworks are being developed and existing frameworks are being updated to include the determinants of equity (107, 108). Researchers are also asked to consider how implementation strategies can be applied at the macro level to dismantle existing power structures (i.e., structural racism). Such actions are aimed at making equity one of the highest priorities in implementation science. Practical recommendations for embedding an equity approach in implementation research include (109): 1) identifying and establishing formal partnerships with stakeholders related to equity so they can participate fully in the implementation process; 2) overlaying an equity lens when deciding which EBIs should be implemented; 3) exploring the implementation gap in specific population groups who may typically experience greater inequality (priority population groups); and 4) identify and prioritise determinants which act as greater barriers for priority population groups (such as structural racism and power imbalances).

Finally, creating teams of practitioners and scientists to work together on implementation issues is recommended (101). However, top-down approaches persist where researchers often decide on the EBI needed for implementation instead of communities and stakeholders determining their needs. Further, the rapid advancements in implementation science mean interprofessional education and training are needed to embed implementation research in practice (104). This includes designing and conducting pragmatic research within healthcare settings, increasing the use of evidence-based implementation strategies and conducting real-time evaluations of outcomes (101).

The introductory sentence in this thesis reads that *implementation science is enjoying its moment in the spotlight*. This is true, and through this thesis, many of the foundational principles of implementation science have been applied to advance our knowledge of how exercise EBIs can be implemented in the treatment of mental illness and cancer. Nevertheless, many pressing issues are emerging that will require attention from researchers and practitioners so the field can live up to its much-lauded promises. Retaining implementation practice at its heart will be central to this.

8.3 Strengths and limitations

As this thesis comprises several publications, the specific limitations of each study are provided in the chapters. However, the overarching strengths and limitations of the body of work are addressed. This thesis sought to contribute to the knowledge of the later stages of implementation by measuring penetration and sustainability. Implementation scientists recommend measuring sustainability prospectively and across multiple time points to account for likely changes that impact sustainability (68). However, there is little consensus about the timeframes for bounding sustainability, with studies varying from 6 months to several years (68). Further, sustainment and sustainability are conceptualised differently as the sustained use of an EBI (i.e., sustainment) versus the sustained benefits of an EBI (i.e., sustainability) (45, 71, 110). The definition of sustainability adopted for this thesis did not delineate between these two terms and encompasses elements of sustained use and sustained benefits. Further, among other constructs, sustainability was operationalised as the delivery of an exercise EBI for at least 12 months and measured at only one-time point throughout the study. However, we believe the multi-construct definition, measured across implementation levels, and the use of a validated measurement instrument are strengths of our approach to sustainability.

Next, the systematic reviews conducted through this thesis excluded non-English studies. Addressing inequity through implementation science is a high priority (106, 111). The failure to include non-English studies in the reviews is at odds with this priority and needs to be addressed in future research.

Finally, due to COVID-19, a multiple case study of exercise EBIs in mental illness was not completed. A single case study was conducted in place (refer to Chapter 5). The selection of sites for a single case study typically differs from that for a multiple case study (112). Single case studies are selected because they represent a unique, different or, extreme phenomenon. By contrast, multiple case studies provide the opportunity to replicate findings, with sites typically chosen because they have specific characteristics in common. When it became apparent that additional case site visits to mental healthcare sites would not be possible, a decision was made to remain faithful to the initial case study protocol pertaining to cases selection criteria. In Chapter 1, it was noted that the maturity of implementation research concerning exercise EBIs and the treatment of cancer and mental illness differs through the almost decade separating exercise EBIs inclusion in clinical practice guidelines. Hence, it could be argued that the routine implementation of exercise in mental healthcare is a somewhat unique phenomenon, and documenting this process through a single case study is justified. Further, because I worked directly with practitioners, the case study provided staff with the opportunity to reflect on their service. We, therefore, believe the benefits for implementation practice justify the pragmatic adaptions made to this case study.

8.4 Conclusion

This thesis aimed to understand how exercise EBIs are integrated into routine practice to treat NCDs, specifically focusing on two conditions, mental illness and cancer. It applied many of the fundamental principles of implementation science to explore the research-to-practice-gap and addressed many contemporary research priorities put forth by implementation scientists. The research-to-practice gap was explored at several junctures, by conducting evidence synthesis using methods that are better suited to implementation practice and conducting implementation research to explain the implementation process.

By applying two novel evidence synthesis methods, we identified that: 1) most evidence in mental illness and exercise investigates the clinical impacts of the EBI, but relatively limited evidence on the cost or safety of exercise EBIs exists; and 2) most pragmatic, real-world studies on the use of exercise EBIs in cancer care were effectiveness studies, and very few of them involved explorations of the late stages of implementation (i.e., penetration and sustainability). Despite the research gaps identified through the systematic reviews, the novel evidence synthesis methods were used to produce information relevant to implementation practice that would not have been possible to uncover through traditional evidence synthesis methods.

The implementation research conducted in this thesis provided insights into how different healthcare organisations have successfully implemented exercise EBIs. Several complementary and interrelated pathways were documented using a comprehensive and theoretically informed approach to develop an explanation of the implementation process that occurred at each site and across sites. We theorise that this contributed to different implementation outcomes and the ongoing delivery of exercise EBIs at case sites. Notably, this work culminated in the development of 11 causal pathways that can inform future implementation efforts. Existing exercise EBI services can also review practices against these

11 pathways to identify areas for optimisation. We concluded by providing a simple summary and examples of typical activities comprising these pathways to facilitate implementation practice.

There is much scope to build on the findings of this thesis. An increased focus on the later phases of implementation and the application of a translational lens to research are needed. This can improve the integration of exercise EBIs in routine care. Working towards this goal will assist international efforts to increase population-wide physical activity levels in people with NCDs, such as mental illness and cancer. Realising this goal will ensure that individuals, communities and society experience the many benefits that regular exercise can provide.

8.5 References

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APPENDIX

1.0 Additional publications

Fibbins H, **Czosnek L**, Stanton R, Davison K, Lederman O, Morell R, Ward P, and Rosenbaum S. Self-reported physical activity levels of the 2017 Royal Australian and New Zealand College of Psychiatrists (RANZCP) conference delegates and their exercise referral practices. *Journal of Mental Health*. 2018; 29:1-8. doi.org/10.1080/09638237.2018.1521935.

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Fibbins H, Ward P, Stanton R, **Czosnek L**, Cudmore J, Michael S, Steel Z and Rosenbaum S. Embedding an exercise professional within an inpatient mental health service: A qualitative study. *Mental Health and Physical Activity*. 2019; 17. doi.org/10.1016/j.mhpa.2019.100300.

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Figure 2: The leaking pipeline depicting the multiple points where knowledge is lost as it progresses for practice. *Re-produced from:* Lawrence W Green, Making research relevant: if it is an evidence-based practice, where's the practice-based evidence?, *Family Practice*, Volume 25, Issue suppl_1, December 2008, Pages i20–i24. doi: 10.1093/fampra/cmn055, by permission of Oxford University Press

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Title of your work	Integrating exercise interventions into routine care for mental illness and cancer: An implementation science approach
Publisher of your work	Australian Catholic University
Expected publication date	Jan 2023
Permissions cost	0.00 AUD
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Total	0.00 AUD
Title	Integrating exercise interventions into routine care for mental illness and cancer: An implementation science approach
Institution name	Australian Catholic University
Expected presentation date	Jan 2023
Portions	Figure 1
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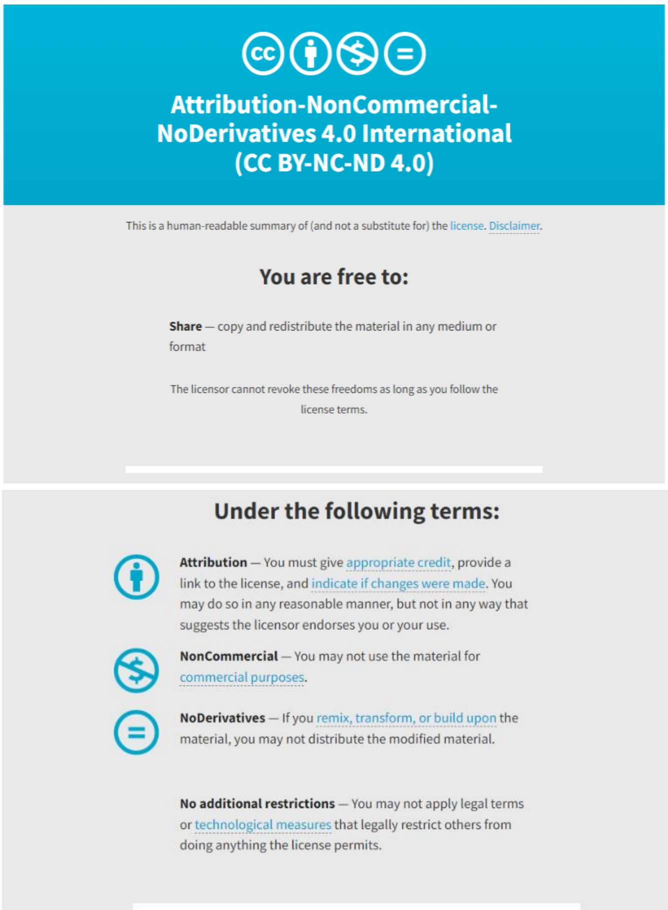
Figure 3: The research translation stages and focus of studies. *Reproduced from:* Deenik J, Czosnek L, Teasdale SB, Stubbs B, Firth J, Schuch FB, et al. From impact factors to real impact: Translating evidence on lifestyle interventions into routine mental health care. Translational Behavioral Medicine. 2020;10(4):1070-3. doi: 10.1093/tbm/ibz067 (*Adapted from Brown et al. 2017 (1)*)



Chapter 2: **Czosnek L**, Rankin N, Zopf E, Richards J, Rosenbaum S, Cormie P. Implementing exercise in healthcare settings: The potential of implementation science. *Sports Medicine*. 2020 January;50(1):1-14. doi.org/ 10.1007/s40279-019-01228-0

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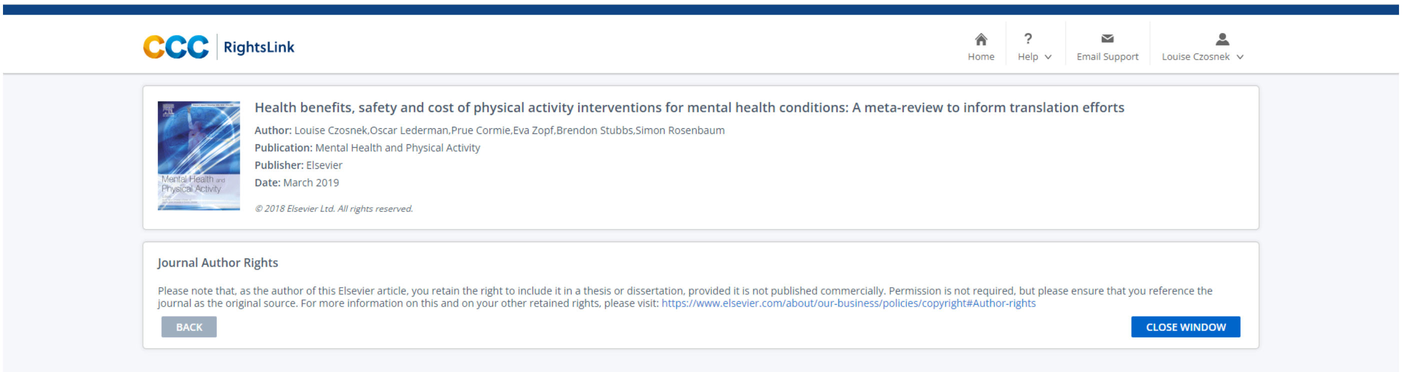

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Health benefits, safety and cost of physical activity interventions for mental health conditions: A meta-review to inform translation efforts

Author: Louise Czosnek,Oscar Lederman,Prue Cormie,Eva Zopf,Brendon Stubbs,Simon Rosenbaum

Publication: Mental Health and Physical Activity

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Exercise interventions for people diagnosed with cancer: a systematic review of implementation outcomes

Author: Louise Czosnek et al

Publication: BMC Cancer

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Author: Louise Czosnek et al

Publication: Implementation Science Communications

Publisher: Springer Nature

Date: Aug 16, 2022

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Author: Louise Czosnek et al

Publication: Supportive Care in Cancer

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3.0 Publication co-author contribution statements

Chapter 2: **Czosnek L**, Rankin N, Zopf E, Richards J, Rosenbaum S, Cormie P. Implementing exercise in healthcare settings: The potential of implementation science. *Sports Medicine*. 2020 January;50(1):1-14. doi.org/ 10.1007/s40279-019-01228-0

As co-author of the manuscript "*Implementing exercise in healthcare settings: The potential of implementation science",* I acknowledge that Louise Czosnek has led and made a primary contribution to the study through:

• Development of study concept and design

• Data collection and analysis of findings

• Writing the manuscript

I confirm that Louise's contribution exceeds 50% of the above-stated paper.

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Chapter 7: **Czosnek L**, Rankin N, Cormie P, Murnane A, Turner J, Richards J, Rosenbaum S, Zopf, E. "Now is the time for institutions to be investing in growing exercise programs as part of standard of care": A multiple case study examining the implementation of exercise oncology interventions. *Supportive Care in Cancer*. 2023 June 26;31(7):422. Doi: 10.1007/s00520-023-07844-x

As co-author of the manuscript *" "Now is the time for institutions to be investing in growing exercise programs as part of standard of care": A multiple case study examining the implementation of exercise oncology interventions"* I acknowledge that Louise Czosnek has led and made a primary contribution to the study through:

• Development of study concept and design

• Data collection and analysis of findings

• Writing the manuscript

I confirm that Louise's contribution exceeds 50% of the above-stated paper.

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4.0 Publication supplementary materials

Chapter 3: **Czosnek L**, Lederman O, Cormie P, Zopf E, Stubbs B, Rosenbaum S. Health benefits, safety and cost of physical activity interventions for mental health conditions: A meta-review to inform translation efforts. *Mental Health and Physical Activity*. 2019 March;16:140-151. doi.org/10.1016/j.mhpa.2018.11.001

Supplemental Table 1: Search strategy - mental health/exercise/effectiveness

	Exercise	Mental Health	Effectiveness (i.e. PIOC) Outcomes (clinical, safe, cost)	Publication Type	NOT
Medline Title/ Abstract terms	exercis* OR "weight lifting" OR sport* OR "strength training" OR "resistance training" OR aerobic OR walk* OR fitness OR "physical activit*"	"mental ill*" OR "mental disord*" OR depress* OR anxiety* OR schizophren* OR psychosis OR psychotic OR "post traumat*" OR "posttraumatic*" OR "post-traumatic*" OR stress* OR "mental health*" OR bipolar	*COST* economic* OR cost* OR budget OR finance* OR *SAFETY* safe* OR accept* OR "side effect" OR "side-effect" OR undesir* OR harm* OR adverse* OR tolera* OR react* OR negative OR reduce* OR minimize OR minimise OR CLINICAL "quality of life" OR symptom* OR sign* OR "tertiary prevent*" OR outcom* OR morbid* OR mortalit* OR surviv* OR death OR recur* OR "body composition" OR "body mass index" OR "mass index" OR "waist circumference" OR "adipose tissue" OR anthropometry OR "cardio-vascular disease" OR diabetes OR "diabetes mellitus" OR "type 2" OR "well-being" OR function* OR hospitalisation OR hospitalization OR burden OR "QOL" OR re-admission* OR readmission* OR fatigue OR "treatment sequela" OR "treatment effect*"	AB ("systematic review" OR "meta-analy*" OR "systematic literature review" OR "meta synthesis" OR "meta-synthesis" OR "meta-synthesis" OR "meta-review" OR "meta review") OR TI ("systematic review" OR "meta-analy*" OR "systematic literature review" OR "meta synthesis" OR "meta-synthesis" OR "meta-synthesis" OR "meta-review" OR "meta review")	rat OR rats OR mice OR rodent* OR mouse
Medline MeSH terms	(MH "Exercise Therapy") OR (MH "Exercise") OR (MH "Plyometric Exercise") OR (MH "Resistance Training") OR (MH "Physical Conditioning, Human") OR (MH "Muscle Stretching Exercises") OR (MH "Circuit-Based	(MH "Mental Disorders") OR (MH "Mentally Ill Persons") OR (MH "Stress Disorders, Post-Traumatic") OR (MH "Stress, Physiological") OR (MH "Depression") OR (MH "Bipolar Disorder") OR (MH "Depressive Disorder")	(MH "Costs and Cost Analysis") OR (MH "Cost-Benefit Analysis") OR (MH "Cost Savings") OR (MH "Cost of Illness") OR (MH "Drug-Related Side Effects and Adverse Reactions") OR (MH "Long Term Adverse Effects") OR	(ZT "meta-analysis")	(MH "Animals")

	Exercise") OR (MH "Exercise Movement Techniques") OR (MH "Walking") OR (MH "Weight Lifting") OR (MH "Sports")	OR (MH "Depressive Disorder, Major") OR (MH "Anxiety") OR (MH "Anxiety Disorders") OR (MH "Schizophrenia") OR (MH "Psychotic Disorders") OR (MH "Mental Health")	(MH "Tertiary Prevention") OR (MH "Quality of Life") OR (MH "Signs and Symptoms") (MH "Treatment Outcome") OR (MH "Patient Reported Outcome Measures") OR (MH "Outcome Assessment (Health Care)") OR (MH “Recurrence") OR (MH "Disease-Free Survival") OR (MH "Survival") OR (MH "Death, Sudden") OR (MH "Death") OR (MH “Cardiovascular Diseases”) OR (“Diabetes Mellitus”) OR (“Diabetes Mellitus, Type 2”) OR (“Fatigue”)		

Supplemental Table 2: Summary of Results

Review	Main Findings							Quality of the evidence AMSTAR	Main conclusion	Comments
	Symptoms of mental illness		Quality of life		Physical health symptoms		Adverse events			
	Standard diff. in mean (SDM), 95% confidence interval (95%CI), p-value, Heterogeneity (I2)	Pooled summary effect size	Standard diff. in mean (SDM), 95% confidence interval (95%CI), p-value, Heterogeneity (I2)	Pooled summary effect size	Standard diff. in mean (SDM), 95% confidence interval (95%CI), p-value, Heterogeneity (I2)	Pooled summary effect size	NA= adverse events were reported in study and no adverse events found			
Interventions for Depression										
Blake, 2009	7 studies depressive symptoms (immediately post-intervention); 5 studies significant reduction in symptoms	Effect favours exercise intervention					Not reported in the study	High	Most studies demonstrated a significant effect for exercise in reducing depressive symptoms immediately post-intervention. Medium-term results demonstrate a positive relationship, although a non-significant trend. Most studies do not measure long-term outcomes. More long-term, well-	Most studies involved group exercise thus it is not possible to rule out the social effects contributing to positive outcomes. Large heterogeneity in results so meta-analysis was not possible. The quality of included studies demonstrated variation across studies (common areas of downgrading
	6 studies depressive symptoms (3-12 months); limited or conflicting evidence of the benefit of exercise in the medium term	Inconclusive								

	2 studies depressive symptoms (>12 months); mixed results: positive results for aerobic exercise, not for resistance exercise	Inconclusive							designed RCT's required.	included allocation concealment and investigator blinding). Further, some reported differences between groups in baseline measures.
Cramer, 2017	5 studies depressive and anxiety symptoms (yoga vs attention control); conflicting evidence	Inconclusive					NA (author concluded that the safety of the interventio n remains largely unclear)	Medium	Yoga produces similar outcomes when compared with medication or exercise. It is not as effective when compared to electro-convulsive therapy and conflicting evidence was found when comparing yoga to attention control and as an add-on. No recommendations for or against yoga as an alternative or adjunct treatment are provided.	The quality of included studies varied with some studies demonstrating a high risk of bias in selective reporting, incomplete outcomes, and blinding of personnel. Selection bias was unclear across all included studies. A low number of eligible RCTs and heterogeneity of interventions, participants and control groups precluded MA.
	1 study depressive symptoms (yoga vs exercise); no difference between groups	No difference								
	1 study depressive severity (yoga vs electro-convulsive therapy); positive effect of electro-convulsive therapy, significant	Positive short-term effects of electro-convulsive therapy but no difference in remission rates								
	1 study depressive symptoms (yoga vs medication); no difference between groups	No difference								

	3 studies depressive symptoms (yoga vs medication (as add-on)); 2 studies positive effect, 1 study no group difference; conflicting evidence	Inconclusive								
Eriksson, 2011	8 studies depressive symptoms; 7 studies positive effects of exercise, 1 study no effect	Effect favouring exercise, significant (in 5 studies)					Not reported in the study	Low	Physical exercise can be an effective treatment for depression	The quality of included studies was reported as mixed. Effect size, where calculated, was modest even with studies of large participant numbers. Results should be interpreted with caution.
Heinzel, 2015	18 studies depressive symptoms; SMD = -0.68; 95%CI = -0.93 to -0.43; p<0.001, I^2=71%	Moderate effect favouring exercise, significant					NA	Medium	The overall effect size (SMD) exploring the anti-depressive effect of physical activity interventions in older adults was found to be in favour of exercise compared to control conditions. The effect size was moderate. Physical exercise may be a feasible	The quality of included studies was fair to high (PEDro). There was large heterogeneity in MA and sub-analysis thus results must be interpreted with caution. Low sample size in some sub-group analysis. Further studies are required that look at moderators such as exercise intensity,
	6 studies depressive symptoms (aerobic exercise); SMD = -0.64; 95%CI = –1.06 to –0.22, p=0.003, I^2=71%;	Moderate effect favouring exercise, significant								

	4 studies depressive symptoms (resistance exercise); SMD = –0.76, 95%CI = –1.43 to –0.09, p=0.03, I^2=72%	Moderate/ large effect favouring exercise, significant							intervention for older people with depression.	duration and frequency.
	5 studies depressive symptoms (alternate exercise); SMD = –0.97, 95%CI = —1.58 to –0.36, p=0.002, I^2=74%	Large effect favouring exercise, significant								
	3 studies depressive symptoms (aerobic exercise + resistance exercise); SMD = –0.28, 95%CI = –0.50 to –0.05, p=0.02, I^2=0%	Small effect favouring exercise, not significant								
	16 studies depressive symptoms (supervised exercise); SMD = –0.77, 95%CI = –1.03 to –0.52, p<0.001, I^2=59%	Moderate/ large effect favouring exercise, significant								
	2 studies depressive symptoms (home-based exercise); SMD = –0.14, 95%CI = –0.43 to 0.15, p=0.35, I^2=49%	Small/ no effect favouring exercise, not significant								

Kvam, 2016	23 studies depressive symptoms; Hedges g = -0.68, 95%CI = –0.92 to -0.44, p<0.001, I^2= 67.99%	Moderate effect favouring exercise, significant					Not reported in the study	High	Exercise is an effective intervention compared to various types of controls. The effect is particularly high when compared with no treatment. It may be a feasible intervention for people to commence given wait times after referral for psychotherapy. It could be considered an effective stand-alone treatment or as adjunct therapy together with anti-depressants. Notably the effect size appears to dissipate after the intervention is ceased.	The lack of high-quality studies makes definitive conclusions and generalisations difficult. 7 of 23 studies used all 3 measures of quality assessment (blinding, allocation concealment and intention to treat). Potential use of anti-depressants before starting exercise treatment - the impact of this is unknown. Moderate to high heterogeneity in MA.
	7 studies depressive symptoms (control follow-up); Hedges g= -0.22, 95%CI = -0.53 to 0.09, p= 0.16, I^2= 46.96%	Small effect favouring exercise, non-significant								
	4 studies depressive symptoms (no intervention); Hedges g= -1.24, 95%CI = -1.83 to -0.65, p<0.001, I^2 = 33.04%	Large effect favouring exercise, significant								
	4 studies depressive symptoms (usual care); Hedges g= -0.48, 95%CI = -0.80 to -0.16, p<0.001, I^2 = 16.25%	Moderate effect favouring exercise, significant								
	3 studies depressive symptoms (psychological care); Hedges g= -0.22, 95%CI = -0.65 to 0.21, p=0.31, I^2=0%	Small effect favouring exercise, non-significant								

	3 studies depressive symptoms (anti-depressants); Hedges g= -0.08, 95%CI = -0.33 to 0.18, p=0.55, I^2=0%	No effect, non-significant								
	3 studies depressive symptoms (exercise + anti-depressants vs medication only); Hedges g= -0.5, 95%CI = -1.10 to 0.11, p=0.11, I^2= 70.87%	Moderate effect favouring exercise medication, non-significant								
Krogh, 2011	13 studies depressive symptoms; Hedges g=-0.04, 95%CI= -0.66 to -0.14, p=0.005, I^2=57.2%	Small effect favours exercise to reduce depressive symptoms, significant					Not reported in the study	Medium	Exercise may have small, short-term effects in reducing depressive symptoms. However, no significant effect is seen in long-term follow-up after 10 weeks. This suggests effects of exercise interventions are short-lived and do not extend beyond the end of the intervention.	The low number of included studies limits the power of the MA. Quality of studies included in the review varied, with authors noting that more recent reviews were of higher quality.
	5 studies depressive symptoms (long-term follow-up); Hedges g=-0.01, 95%CI= -0.28 to -0.26, p=0.265, I^2=23.4%	Small/No effect, non-significant								
Schuch, 2016(a)	25 studies depressive symptoms; SMD=0.98, 95% CI=0.68 to 1.28, p<0.001	Large effect favouring exercise, significant					Fail-safe number = 1057	High	Exercise is an effective evidence-based treatment for depression. The results of the MA found large anti-	Four studies were assessed as good quality (and low risk of bias) the remaining 21 studies were

	of 25 above 9 re-calculated to account for publication bias, depressive symptoms; SMD = 1.11, 95% CI = 0.79 to 1.43, $p<0.001$	Large effect favouring exercise, significant							depressant effects for exercise when compared with non-active controls. Publication bias appeared to underestimate the effects of exercise. In sub-group analysis supervised exercise sessions appeared to have better anti-depressant effects than unsupervised interventions and moderate to vigorous intensity exercise had increased effects compared to lower intensity activity. Both aerobic and mixed (aerobic+ resistance) modes of exercise appear beneficial.	assessed as low quality (high risk of bias). The conclusions for the intensity of exercise and resistance/mixed mode need to be considered with caution due to the small number of included studies.
	3 studies (light/moderate intensity exercise); SMD = 0.586, 95% CI=-0.019 to 1.190, p=0.058, I^2=32.96%	Moderate effect favouring exercise, non-significant								
	6 studies (moderate intensity exercise); SMD=1.330, 95%CI= 0.463 to 2.197, p=0.003, I^2=83.37%	Large effect favouring exercise, significant								
	7 studies (vigorous intensity exercise); SMD = 1.342, 95%CI= 0.437 to 2.246, p=0.004, I^2=91.09%	Large effect favouring exercise, significant								
	19 studies (aerobic exercise); SMD=1.045, 95%CI=0.653 to 1.437, $p<0.0001$, I^2=80.97%	Large effect favouring aerobic exercise, significant								

	3 studies (resistance exercise); SMD=1.152, 95%CI=-0.50 to 2.801, p=0.174, I^2-93.40%	Large effect favouring resistance exercise, non-significant								
	3 studies (aerobic exercise + resistance exercise/mixed); SMD=0.659, 95%CI=0.248 to 1.069; p=0.002, I^2=48.39%	Moderate effect favouring mixed, significant								
	13 studies (group exercise); SMD=0.924, 95%CI=0.513 to 1.336, p<0.0001, I^2=76.10%	Large effect favouring group exercise, significant								
	8 studies (not group exercise); SMD=1.531, 95%CI=0.775 to 2.288, p<0.0001, I^2=90.38%	Large effect favouring non-group exercise, significant								
	18 studies (supervised exercise); SMD=0.906, 95%CI=0.054 to 1.271, p<0.0001, I^2=80.34%	Large effect favouring supervised exercise, significant								
	3 studies (unsupervised exercise); SMD=1.074, 95%CI=-0.400 to 2.549, p=0.153, I^2=77.20%	Large effect favouring unsupervised exercise, non-significant								

Sukhato, 2017	2 studies, depressive symptoms (home-based exercise + psychological intervention); SMD=-0.78, 95%CI=-0.19-0.47, I^2=0%	Moderate/ large effect favouring home-based exercise + psychological intervention, significant					NA	Medium	Home-based exercise combined with psychological interventions were effective in reducing depressive symptoms.	Small number of studies included in MA and large heterogeneity in the exercise-only group, thus interpret results with caution. The authors reported variance in quality of included studies.
	3 studies depressive symptoms (home-based exercise only); SMD=−1.03, 95%CI=−2.89 to 0.82, I^2=97.9%	Large effect favouring home-based exercise, non-significant								
Schuch, 2016(b)			5 studies QOL (overall); SMD=0.39, 95%CI = 0.47 to 0.74, p=0.002, I^2=0%	Small/ moderate effect favouring exercise, significant			Fail safe number = 71	Medium	Exercise significantly improves physical, psychological, and overall QOL. Non-significant effects were seen in the social and environmental domains. Better-designed trials are required to determine the impact of exercise and participants characteristics on QOL domains in comparison to anti-depressant medication.	A low number of studies included in the systematic review, however low heterogeneity increases confidence in results. 5 of 6 included studies were reported as low quality.
			5 studies QOL (physical domain); SMD=0.53, 95%CI = 0.22 to 0.84, p<0.001, I^2=0%	Moderate effect favouring exercise, significant						
			5 studies QOL (psychological domain); SMD=0.53, 95%CI = 0.22 to 0.85,	Moderate effect favouring exercise, significant						

			p<0.001, I^2=4.89%							
			5 studies QOL (social domain); SMD=0.28, 95%CI = -0.13 to 0.71, p=0.18, I^2=13.04%	Small effect favouring exercise, non-significant						
			5 studies QOL (environmental domain); SMD=0.36, 95%CI = -0.12 to 0.85, p=0.14, I^2=30.75%	Small effect favouring exercise, non-significant						
Schuch, 2016(c)	8 studies depressive symptoms; SMD=-0.90, 95%CI = 0.28 to 1.51, p=0.004, I^2=81.63%	Large effect favouring exercise, significant					Not reported in the study	Medium	Large and significant effects of exercise in reducing depressive symptoms in older adults. Specifically, moderate-intensity exercise incorporating both aerobic and resistance training conducted in a group setting produced the best results.	Some caution is needed when interpreting results given the limited number of included studies. The authors suggest previous studies may have underestimated the effects of exercise due to publication bias. All included studies were of low quality (high risk of bias).
	1 study depressive symptoms (moderate intensity exercise); SMD = -0.73, 95%CI=0.08 to -1.38, p=0.02, I^2=0%	Moderate effect favouring exercise, significant								
	3 studies depressive symptoms (vigorous intensity exercise); SMD	Large effect favouring exercise, non-significant								

	= -1.15, 95%CI=0.50 to -2.80, p=0.17, I^2=93.47										
	3 studies depressive symptoms (aerobic exercise); SMD = -0.66, 95%CI=0.10 to -1.42, p=0.09, I^2=65.82	Moderate effect favouring exercise, non-significant									
	3 studies depressive symptoms (resistance exercise); SMD = -1.15, 95%CI=0.50 to -2.80, p=0.174, I^2=93.40	Large effect favouring exercise, non-significant									
	2 studies depressive symptoms (aerobic exercise + resistance exercise/mixed); SMD = -0.92, 95%CI=-0.41 to -1.43, p<0.0001, I^2=0%	Large effect favouring exercise, significant									
	6 studies depressive symptoms (group exercise); SMD = -0.97, 95%CI=-0.24 to -1.71, p=0.009, I^2=84.35%	Large effect favouring exercise, significant									

	2 studies depressive symptoms (no group exercise); SMD = -0.69, 95%CI=0.78 to -2.36, p=0.356, I^2=82.49%	Moderate effect favouring exercise, non-significant								
	6 studies depressive symptoms (supervised exercise); SMD = -0.86, 95%CI=-0.07 to -1.66, p=0.032, I^2=85.19%	Large effect favouring exercise, significant								
Stubbs, 2016					8 interventions (from 7 studies) CRF; g= 0.64, 95% CI=-0.32 to 0.96, p<0.001, I^2=67%	Moderate effect favouring exercise to improve VO_2, significant	Not reported in the study	Medium	Exercise can improve CRF in people with depression in a relatively short period of time (12 weeks). These results support calls for exercise to be included in routine care for depression.	Small number of RCTs, participants and moderate heterogeneity in results. Quality assessment completed, however unable to determine the quality of included studies.
Interventions for Schizophrenia Disorders										
Dauwan, 2016	14 studies total (positive and negative symptoms); Hedges g=0.39, 95%CI= 0.19–0.58, p<0.001, I^2=61%	Small/ moderate effect favouring exercise, significant	11 studies QOL (total - physical, mental, social and environment); Hedges g=0.55, 95%CI= 0.35–0.76, p<0.001, I2=49%	Moderate effect favouring exercise, significant			Not reported in the study	Medium	Overall significant effect of exercise on improving total symptoms of schizophrenia and QOL.	The quality of included studies was mixed, particularly with respect to blinding assessment. Moderate heterogeneity within studies.

Keller-Varady, 2017	2 studies symptoms of schizophrenia (resistance exercise only); mixed results: 1 study no improvement in symptoms or QOL outcomes. 1 study significant improvement in symptoms	Inconclusive					Not reported in study	High	Interventions that combine strength and aerobic training demonstrated improvements in muscle strength, physical fitness and symptom severity. Combined training should be recommended for people with schizophrenia.	The quality of included studies was mixed.
	5 studies (aerobic exercise + resistance exercise/mixed)	Effect favouring exercise in reducing symptom severity								
Firth, 2015	16 studies (8 included in MA) psychiatric symptoms; SMD = −0.16, 95% CI −0.51 to 0.18, I^2=54%	Small effect favouring exercise, not significant	4 studies QOL; 2 positive change (with 120 mins moderate/ vigorous); 2 studies no change	Inconclusive	Of 11 studies, 10 observed significant outcomes in at least one physical health measure (i.e., BMI, waist circumference, body weight, fitness). 4 studies pooled for MA of BMI; Mean difference = -0.98kg, 95%CI = -3.17-1.22.	(For MA) small effect in favour of exercise, not significant	NA	High	The intensity and duration of exercise are important. By excluding studies that used low-intensity exercise, results suggest moderate-to-vigorous intensity exercise significantly improved total symptom scores. No changes were seen in physical health measures, but physical fitness did improve which is important in	4 of the 8 trials included in the MA investigating change in symptoms implemented exercise as a 'physical activity control' for yoga. Recommendation for larger scale RCTs of exercise intervention trials. The quality of included studies was mixed, with a high risk of bias (greater than 50% of included studies)

	4 studies (moderate to high intensity exercise) psychiatric symptoms; SMD = −0.72, 95% CI −1.14 to −0.29, I^2=0%	Moderate/ large effect favouring exercise, significant			7 studies reported changes in physical fitness using VO_2. 3 studies reported clinically significant increases in VO_2 to reduce cardiovascular disease risk				protecting against cardiovascular disease. At least 90 minutes of moderate-high-intensity exercise is recommended.	reported in attrition bias.
Martin, 2017	5 studies reported an improvement in the mental health variable assessed. 4 studies reported statistically significant improvements	Effect size varied across studies, but all favoured exercise, significant			3 studies VO_2, 3 studies strength outcomes	VO_2 - low effect size favouring exercise, non-significant. Strength - Effect size varied across studies but all favoured exercise, significant	Not reported in the study	Medium	Exercise improved mental health outcomes, however, reporting of exercise protocols is poor making it difficult to detail optimal exercise prescription for this population group.	The authors noted the included studies have a high risk of bias and are low-quality studies, meaning results must be interpreted with caution.
Vancampfort 2015					5 studies CRF in population diagnosed with schizophrenia vs age-match control; SMD= 0.96, 95% CI= 1.29 to 0.64, I^2=55% (low to moderate)	Large difference in CRF between population diagnosed with schizophrenia vs age-match control	NA	Medium	People with schizophrenia have poorer CRF compared with age/gender-matched controls. Preliminary evidence suggests physical activity can improve CFR in people with schizophrenia.	The quality of included studies is not reported. No long-term follow-up data were available and results were based upon exercise interventions of 6 weeks to 6 months.

					Physical activity was shown to prevent the progressive decrease in CRF in chronic patients and results in CRF improvements in younger and chronic patients				Exercise programs should be viewed as a standard component of routine care and not a 'luxury' or adjunct treatment given the association between CRF and cardiovascular disease and mortality.	
Vancampfort 2015 (a)					Exercise and change in CRF; Hedges g=0.40, 95%CI = 0.16 to 0.64, p = 0.001, I^2=65%(moderate)	Small/ moderate effect favouring exercise in improving CRF, significant	Not reported in the study	Medium	Aerobic exercise increased predicted VO_2max or VO_2peak and produced better results than control conditions. The results support a shift in focus from BMI/weight loss to improving CRF in this population due to the association between CRF and cardio-vascular disease and mortality.	Results must be interpreted with caution due to the small number of participants and limited reporting of other possible co-founding variables. Quality assessment of included studies not reported.
					4 studies (exercise vs control); Hedges g=0.43, 95%CI = 0.05 to 0.82, p=0.02, I^2=0%	Small/Moderate effect favouring exercise in improving CFR, significant				
Vancampfort 2012	2 studies psychiatric symptoms (total); reduced after yoga intervention	Effect favouring yoga	2 studies; physical, psychological, social and environmental QOL increased	Effect favours yoga			3 studies, NA	Medium	Yoga therapy can reduce psychiatric symptoms and improve QOL. No adverse events were reported and it is suggested that yoga be viewed as an encouraging complementary therapy.	Limited number of RCTs in this area. The results must also be interpreted with caution because of the diversity in yoga interventions, duration and frequency. Primary concern reported about
	3 studies psychiatric symptoms (positive and negative	Effect favouring yoga								

	symptoms); reduced after yoga intervention									methodological quality is low participant numbers.
Zheng, 2016	5 studies psychiatric symptoms (negative); SMD= -0.87, 95%CI=-1.15 to -0.24, p=0.007, I^2=90%	Large effect favouring Tai Chi, significant					NA	Medium	Regular Tai Chi improved negative symptoms but had no effect on positive symptoms. Tai Chi may also improve social functioning, abnormal behaviours, and cognitive function.	The methodological quality of studies was mixed. The quality of the evidence base and strength of recommendations was reported as 'very low' according to GRADE.
	5 studies psychiatric symptoms (positive); SMD= -0.09, 95%CI=-0.44 to 0.26, p=0.60, I^2=65%	No effect, not significant								
Vera-Garcia, 2015	3 studies (aerobic exercise and resistance exercise) psychiatric symptoms (total), reduced significant. 1 study (exercise vs control) psychiatric symptoms (total) reduced significantly, not in control group	Effect favouring exercise intervention in reducing total symptoms and when compared to control, significant	3 studies (aerobic exercise and /or strength training), physical and mental QOL improvement, 2 studies similar improvements in the physical QOL in the relaxation groups. 1 study (high intensity training) no change in QOL				NA	High	Aerobic exercise, strength training and yoga can reduce psychiatric symptoms and improve health-related quality of life. These interventions appear safe, however adherence and drop-out rates are not routinely reported in the literature.	Large heterogeneity in results precluded MA. The quality assessment indicated mixed results with main limitation identified by the author as lack of masking and intention to treat analysis.

	3 studies (yoga) psychiatrics symptoms (total), reduced significantly. 1 study - (yoga) psychiatrics symptoms (negative only), reduced significantly. 1 study (yoga vs exercise group) psychiatric symptoms (negative)	Effect favouring yoga in reducing total and negative symptoms, significant	1 study (yoga) physical and psychological QOL, improve	Effect favouring yoga, significant						
	1 study (Tai Chi) psychiatric symptoms (negative)	No effect								
Soundy, 2015	1 study depressive and anxiety symptoms, significant reduction, p<0.03	Effect favouring sport participation, significant	1 study - physical and psychological QOL, improved, p<0.001	Effect favouring sports participation, significant	3 studies reported weight reduction	Effect favouring sport participants (2 studies significant, 1 non-significant)	Not reported in the study	Medium	Participation in sports may result in a small decrease in weight/ BMI and improve positive and negative symptoms of schizophrenia. Sports participation is enjoyable and can provide a wide range of benefits for people with schizophrenia.	The authors noted a high risk of bias in included studies, inability to conduct a MA due to heterogeneity in results. Low study numbers and sample size and a large portion of male participants.
	2 studies psychiatric symptoms (total), improved. 1 study - no change**	Inconclusive								
Multiple mental health diagnoses										
Rosenbaum, 2014	20 studies depressive symptoms; SMD=0.80, 95%CI = 0.47-	Large effect favouring exercise, significant	6 studies QOL; SMD=0.64, 95%CI = 0.35 to 0.92,	Moderate effect favouring exercise, significant	11 studies anthropometric measure; SMD=0.24, 95%CI=0.006-	Small effect favouring exercise, significant	NA	High	Physical activity interventions reduce symptoms of depression in people with a	Quality of included studies varied (high and low quality on PEDro scale), which impacted the

	1.13, $p<0.001$, $I^2=84\%$		$p<0.001$, $I^2=0\%$		0.41, $p<0.05$, $I^2=0\%$				psychiatric diagnosis. Second physical activity interventions showed a large impact on reducing schizophrenia symptoms. The effect of exercise interventions on anthropometric measures was small.	effect size. Poor reporting of exercise protocols (within included studies) makes replication difficult.
	11 studies (meeting ACSM guidelines); SMD=0.94, 95% CI=0.42-1.45, $p<.001$	Large effect favouring exercise, significant								
	9 studies (not meeting ACSM guidelines); SMD=0.61, 95% CI=0.18-1.04, $p<.01$	Moderate effect favouring exercise, significant								
	8 studies symptoms of schizophrenia; SMD=1.0, 95%CI= 0.37 - 1.64, $p<0.01$, $I^2=88\%$	Large effect favouring exercise, significant								
Klatte, 2016	6 studies (yoga vs untreated control) anxiety symptoms; Hedges g= 0.57, 95%CI = 0.18 to 0.97, p= 0.005, $I^2=62.4\%$	Moderate effect favouring yoga, significant	9 studies (yoga vs un-treated control) Hedges g= 0.60, 95%CI = 0.35 to 0.84, $p<0.001$	Moderate effect size favouring yoga, significant			Not reported in the study	Medium	Comparisons of yoga versus untreated control found significant effects in favour of yoga. Compared to exercise yoga presented a small and significant effect. Yoga presents a positive complementary approach to the treatment of mental illness.	The authors reported substantial heterogeneity, thus results must be interpreted with caution. The quality of included studies varied with the risk of bias reported as high.
	3 studies (yoga vs untreated control) depression; Hedges g = 0.74, 95%CI = 0.37 to 1.10, p <0.001, $I^2=0\%$	Moderate/ Large effect favouring yoga, significant								
	(yoga vs exercise); Hedges g=0.38, 95%CI=0.03-	Small effect favouring yoga, significant								

	0.72, p=0.033, I^2=0%									
Rosenbaum, 2015(a)	2 studies depressive symptoms. Effect favoured exercise intervention						Not reported in the study	Medium	Due to the limited number of studies, no firm conclusions can be drawn. However preliminary results suggest physical activity may have a positive effect on symptoms of depression and participation rates.	The effect size between the two studies varied greatly and the scarcity of results indicates more studies are required. The quality of the included studies was low (PEDro).
Vancampfort, 2017					23 studies CRF value vs control; Hedges g: -1.01, 95%CI = -1.18 to -0.85, p < 0.0001, I^2=47%	People with SMI have significantly lower CRF	Not reported in the study	Medium	People with SMI have significantly lower CRF than age/sex-matched healthy controls. Exercise significantly improves CRF in people with SMI. Better results are observed with higher intensity exercise that is supervised (i.e., by a physiotherapist or exercise physiologist) and completed >3x week. Despite no change in BMI, people with SMI can significantly reduce risk of mortality by increased fitness.	There was some heterogeneity in results and a low number of included studies. The quality of included studies was unable to be determined, however, publication bias was reported.
					13 studies CRF (after exercise intervention); Hedges g: 0.33, 95%CI =0.21 to 0.45, p =0.001, I^2=54.4%	Small effect favouring exercise, significant				
					Duration (<10 weeks vs >10 weeks); SMD=-0.074, 95%CI = -0.33 to 0.81, p=0.58, I^2=58.5%	No effect, non-significant				

					Frequency (<3 vs >3 times per week); SMD=0.33, 95%CI =0.20 to 0.46, $p<0.001$, $I^2=54.5\%$	Small effect favouring >3xweek, significant				
					Intensity (low/moderate vs high); SMD=0.33, 95%CI =0.20 to 0.46, $p<0.001$, $I^2=54.5\%$	Small effect favouring higher intensity, significant				
					Exercise provider (qualified vs not); SMD=0.27, 95%CI =0.04 to 0.50, $p=0.02$, $I^2=54.9\%$	Small effect favouring qualified staff, significant				
					Aerobic exercise significantly improved CRF (Hedges g = 0.37, 95 % CI 0.15–0.59, $p<0.001$). No significant change in BMI (Hedges' g = -0.04, 95 % CI -0.15 to 0.07, p = 0.46)					

Stanton, 2016	Exercise is safe and well-tolerated intervention across a range of conditions, including depressive disorders (4 studies), schizophrenia (1 study), bipolar disorder (1 study), and anxiety disorders (2 studies).						Not reported in the study	Medium	Exercise programs delivered in inpatient settings are effective to improve mental health outcomes for a range of mental health conditions.	The quality of included studies varied and limited studies completed. Call for further high-quality RCTs that mandate reporting of clinical exercise protocols.
Interventions for Anxiety Disorders										
Bartley, 2013	7 studies anxiety symptoms; SMD=0.02, 95% CI=−0.20 to –0.24, p=0.85; Heterogeneity X^2=22.7 (significant)	Small effect favouring exercise, non-significant					Not reported in the study	Medium	No significant benefit of aerobic exercise as a primary treatment for anxiety disorders. Aerobic exercise did provide significant benefit when compared to placebo or wait-list control. No benefits were observed when compared to traditional treatment (i.e., pharmacotherapy)	The authors noted MA lacked statistical power due to the small number of included studies and participants. There was a large variation in included study quality and significant heterogeneity. Comparisons to active controls (i.e., strength training) were also included.
Jayakody, 2014	1 study anxiety symptom (exercise vs placebo pill), p=significant	Effect favours exercise, significant	1 study QOL symptoms (exercise vs no exercise); p=0.47(at 20 weeks of intervention)	Increase QOL favouring exercise, non-significant			NA	Medium	Exercise interventions showed a beneficial effect compared to placebo, although the anxiolytic effects of exercise	Most studies were of short duration and the quality assessment of included studies indicates most studies fell in the

	1 study anxiety symptoms (exercise vs anti-depressant medication), p=significant	Effect favours control, significant							are less than anti-depressants. Exercise is considered a beneficial adjunct therapy with no reported adverse events.	mid-range on the Cochrane Collaboration on Depression Anxiety and Neurosis (CCDAN) quality rating scores. Moderate heterogeneity was observed.
Stubbs, 2017	6 studies anxiety symptoms; SMD −0.581, 95% CI = −1.0 to −0.76, p=0.02, I^2=66%	Moderate effect favouring exercise, significant					Not reported in the study	Medium	Exercise should be considered an evidence-based option for reducing anxiety symptoms in people with anxiety/stress-related disorders.	Small number of trials of predominantly low quality, interpret results with caution. 5 of the 6 included studies were of low quality, 1 high-quality study. Moderate heterogeneity.
Interventions for Post-traumatic stress disorder (PTSD)										
Rosenbaum, 2015	4 studies PTSD symptoms; Hedges g= -0.35, 95%CI = -0.63 to -0.077, p=0.02, I^2 =0%, Kendall tau=0 (p=0.5), Eggers regression=0.8, (p=0.68)	Small/ moderate effect size favouring exercise, significant			1 study mean between group reduction in waist circumference - 3.6cm (-7.0 to -0.2); p=0.04	Effect favouring exercise, significant	NA	Medium	Physical activity interventions are efficacious in reducing symptoms of PTSD and depressive symptoms in people with PTSD	The quality of included studies was mixed (and assessed across concealed allocation and assessor blinding only). The limited number of included studies makes definitive conclusions difficult.
	3 studies depressive symptoms; Hedges g= 0.37, 95%CI= 0.69 to 0.05, p=0.03, I^2 =17%, Kendall tau=3 (p=0.3), Eggers	Small/ moderate effect size favouring exercise, significant								

	regression=6 (p=0.2)									
Lawrence, 2010	The search strategy identified five papers but none of the studies met the inclusion criteria.						Not reported in the study	NA	More research is needed to determine the effectiveness of sports and games in alleviating symptoms of PTSD.	NA
Intervention for Substance Use (SUD)/Alcohol Use Disorder (AUD)										
Hallgren, 2017	4 studies depressive symptoms; SMD=−0.867, 95%CI = −1.49 to −0.24, p= 0.006 I^2=63%	Large effect favouring exercise, significant			3 studies VO_2; SMD=0.564, 95%CI = 0.11 to 1.01, p=0.01, I^2=46%; moderate effect size, significant	Moderate effect size favouring exercise to improve VO_2, significant	NA	Medium	Exercise can reduce depressive symptoms and improved physical fitness in people with AUD. However, no statistically significant changes were reported in alcohol consumption, symptoms of anxiety or self-efficacy.	The authors reported this is the first MA exploring AUD and exercise. Moderate heterogeneity across studies makes generalised conclusions difficult. The quality of included studies is unknown.
	No impact on alcohol consumption									
Wang, 2014	5 studies abstinence(alcohol); OR = 1.65, 95%CI=1.14-2.39, p<0.001, I^2=31.1%	Effect favouring exercise in alcohol abstinence, significant					Not reported in the study	Medium	Chronic physical exercises can improve the abstinence rate and reduce symptoms of depression and anxiety in illicit drug users. Physical exercise can lessen withdrawal symptoms and symptoms of anxiety and depression in	Some of the included studies had a large number of female participants and the authors noted that females have more difficulty giving up drug addiction. Further, it is difficult to isolate the effects of exercise on the specific condition
	5 studies abstinence (illicit drugs); OR =-4.13, 95% CI 2.39 to 7.14, I^2=43.9%	Effect favouring exercise in illicit drug abstinence								
	2 studies anxiety symptoms	Effect favouring								

	(alcohol); OR =-0.21, 95% CI -0.58 to 0.16, I^2=37.9%	exercise to improve symptoms of anxiety							alcohol and illicit drug addictions.	because polyuse is common. The quality of included studies was mixed (predominantly moderate quality studies). Finally, some heterogeneity was present in results pertaining to withdrawal and exercise effect on depressive symptoms
	3 studies anxiety symptoms (illicit drugs); OR=-0.40, 95% CI -0.64 to - 0.16, I^2=0%	Effect favouring exercise to improve symptoms of anxiety								
	3 studies depressive symptoms(alcohol); OR=-0.77, 95% CI - 1.73 to - 0.19, , I^2=89.2%	Effect favouring exercise to improve symptoms of depressions								
	4 studies depressive symptoms (illicit drugs); OR=-0.51, 95% CI -0.73 to - 0.28,	Effect favouring exercise to improve symptoms of depressions								

vs - Versus, PEDro = Physiotherapy Evidence Database, QOL = Quality of Life, CRF = Cardio-Respiratory Fitness, VO_2= Maximal exercise capacity, BMI = Body Mass Index, ACSM = American College of Sports Medicine, SMI=Serious Mental Illness, AMSTAR = Assessing the Methodological Quality of Systematic Reviews, RCTs = Randomised Control Trials, MA=Meta-Analysis

Supplemental Table 3: Quality Assessment (AMSTAR)

	Was an "a priori" design provided	Was there duplicate study selection and data extraction	Was a comprehensive literature review performed	Was the status of the publication (i.e., grey literature) used as an inclusion criterion	Was the list of studies (included and excluded provided)	Were the characteristics of the included studies provided	Was the scientific quality of the included studies assessed and documented	Was the scientific quality of the included studies used appropriate in formulating conclusions	Were the methods used to combine the findings of studies appropriate	Was the likelihood of publication bias assessed	Was the conflict of interest stated	Total Score	high (8–11 points), medium (4–7 points), or low
Rosenbaum, 2015	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	**7**	Medium
Rosenbaum, 2014	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	**8**	High
Bartley, 2013	No	Yes	Yes	No	No	Yes	No	Can't say	No	Yes	No	**4.5**	Medium
Blake, 2009	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	**8**	High
Cramer, 2017	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	**6**	Medium
Dauwan, 2016	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	**6**	Medium
Ericksson, 2011	No	No	No	No	No	Yes	No	No	No	No	No	**1**	Low
Hallgren, 2017	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	**7**	Medium
Keller-Varady, 2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	**8**	High
Firth, 2015	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	**8**	High
Heinzel, 2015	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	**6**	Medium

	Was an "a priori" design provided	Was there duplicate study selection and data extraction	Was a comprehensive literature review performed	Was the status of the publication (i.e., grey literature) used as an inclusion criterion	Was the list of studies (included and excluded provided)	Were the characteristics of the included studies provided	Was the scientific quality of the included studies assessed and documented	Was the scientific quality of the included studies used appropriate in formulating conclusions	Were the methods used to combine the findings of studies appropriate	Was the likelihood of publication bias assessed	Was the conflict of interest stated	Total Score	high (8–11 points), medium (4 –7 points), or low
Jayakody, 2014	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	**7**	Medium
Klatte, 2016	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	**7**	Medium
Kvam, 2016	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	**9**	High
Lawrence, 2010	NA - The search strategy did not identify any relevant studies	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**NA**	NA
Martin, 2017	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Can't say	No	**5.5**	Medium
Rosenbaum, 2015(a)	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Can't say	No	**7.5**	Medium
Krogh, 2010	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	**6**	Medium
Schuch, 2016(a)	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	**8**	High
Sukhato, 2017	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	**7**	Medium
Vancampfort, 2015	No	Yes	Yes	No	No	Yes	No	No	Yes	Yes	No	**5**	Medium

	Was an "a priori" design provided	Was there duplicate study selection and data extraction	Was a comprehensive literature review performed	Was the status of the publication (i.e., grey literature) used as an inclusion criterion	Was the list of studies (included and excluded provided)	Were the characteristics of the included studies provided	Was the scientific quality of the included studies assessed and documented	Was the scientific quality of the included studies used appropriate in formulating conclusions	Were the methods used to combine the findings of studies appropriate	Was the likelihood of publication bias assessed	Was the conflict of interest stated	Total Score	high (8–11 points), medium (4–7 points), or low
Vancampfort, 2017	No	Yes	Yes	No	No	No	No	No	Yes	Yes	No	**4**	Medium
Vancamfort, 2015(a)	No	Yes	Yes	No	No	Yes	No	No	Yes	Yes	No	**5.5**	Medium
Vancampfort, 2012	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	No	**6**	Medium
Wang, 2014	No	No	No	No	No	Yes	Yes	Yes	Can't say	Yes	No	**4.5**	Medium
Zheng, 2016	No	Yes	Yes	Yes	No	Yes	Yes	Can't say	Yes	Yes	No	**7.5**	Medium
Vera-Garcia, 2015	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	**8**	High
Schuch, 2016(b)	No	Yes	Yes	No	No	Yes	Yes	Yes	yes	Yes	No	**7**	Medium
Schuch, 2016 (c)	No	Yes	Yes	No	Yes	Yes	Can't say	No	Yes	Yes	No	**6.5**	Medium
Soundy, 2015	No	No	Yes	No	No	Yes	Yes	Yes	Yes	No	No	**5**	Medium
Stanton, 2014	No	Can't say	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	**7.5**	Medium
Stubbs, 2016	No	Yes	Yes	No	No	Yes	Can't say	No	Yes	Yes	No	**5.5**	Medium

	Was an "a priori" design provided	Was there duplicate study selection and data extraction	Was a comprehensive literature review performed	Was the status of the publication (i.e., grey literature) used as an inclusion criterion	Was the list of studies (included and excluded provided)	Were the characteristics of the included studies provided	Was the scientific quality of the included studies assessed and documented	Was the scientific quality of the included studies used appropriate in formulating conclusions	Were the methods used to combine the findings of studies appropriate	Was the likelihood of publication bias assessed	Was the conflict of interest stated	Total Score	high (8–11 points), medium (4 –7 points), or low
Stubbs, 2017	No	Yes	Yes	No	No	Yes	Can't say	No	Yes	Yes	No	**5.5**	Medium

Supplemental Table 4: Excluded studies

1 = Lack formal mental health diagnosis (n=73)
2 = Non-adult population (n=6)
3 = Prevention study utilising physical activity (n=2)
4 = Physical activity not main intervention (n=18)
5 = Wrong study design (n=20)
6 = Non-English article (n=20)
7 = Non-human study (n=0)
8 = Outcome of interest not reported (i.e. symptoms, quality of life, physical health metric, adverse event or cost) (n=29)
9 = No comparator (n=0)
N/A = Withdraw or unable to source full text (n=4)

Author	**Year**	**Title**	**Reason**
Alexandratos, Kristy; Barnett, Fiona; Thomas, Yvonne	2012	The impact of exercise on the mental health and quality of life of people with severe mental illness: A critical review	1
Almagro Valverde, S.; Dueñas Guzmán, M.A. y Tercedor Sánchez, P	2014	Physical activity and depression: A systematic review	6
Andersson E, Hovland A, Kjellman B, Taube J, Martinsen E	2015	Physical activity is just as good as CBT or drugs for depression	6
Bauer	2016	Lifestyle interventions targeting dietary habits and exercise in bipolar disorder: A systematic review	4
Bernard, P.; Ninot, G.	2012	Benefits of exercise for people with schizophrenia: A systematic review	6
Bernard, P.; Romain, A. J.; Esseul, E.; Artigusse, M.; Poy, Y.; Baghdadli, A.; Ninot, G.	2013	A systematic review of barriers to physical activity and motivation for adults with schizophrenia	6
Bonfioli, E.; Berti, L.; Goss, C.; Muraro, F.; Burti, L.	2012	Health promotion lifestyle interventions for weight management in psychosis: A systematic review and meta-analysis of randomised controlled trials	2
Bradshaw, T.; Lovell, K.; Harris, N.	2005	Healthy living interventions and schizophrenia: a systematic review	2
Broderick J, Knowles A, Chadwick J, Vancampfort D	2015	Yoga versus standard care for schizophrenia.	2
Cabassa, L. J.; Ezell, J. M.; Lewis-Fernández, R.; Cabassa, Leopoldo J.; Ezell, Jerel M.; Lewis-Fernández, Roberto	2010	Lifestyle interventions for adults with serious mental illness: A systematic literature review	1
Caddick, N.; Smith, B.	2014	The impact of sport and physical activity on the well-being of combat veterans: A systematic review	1
Chacón, F.; Mora, F.; Gervás-Ríos, A.; Gilaberte, I.	2011	Efficacy of lifestyle interventions in physical health management of patients with severe mental illness	5
Chalfoun, C.; Abdel-Baki, A.; Letendre, E.; Proulx, C.; Karelis, A. D.	2015	Improvements in cardiorespiratory health with physical activity in schizophrenic individuals: A practical guide	6
Cheng, F. K.	2015	Effects of Baduanjin on mental health: A comprehensive review	1
Chi, I.; Jordan-Marsh, M.; Guo, M.; Xie, B.; Bai, Z. G.	2013	Tai chi and reduction of depressive symptoms for older adults: A meta-analysis of randomized trials	1
Cox, Janet Gray	2008	Is exercise an evidence-based intervention for clinical depression in older adults: A meta-analysis of randomized studies 2000-2006	5

Author	Year	Title	Reason
Craft, L. L.; Landers, D. M.	1998	The effect of exercise on clinical depression and depression resulting from mental illness: A meta-analysis	1
Cramer, H.; Lauche, R.; Klose, P.; Langhorst, J.; Dobos, G.	2013	Yoga for schizophrenia: A systematic review and meta-analysis	1
Cramer, H.; Lauche, R.; Langhorst, J.; Dobos, G.	2013	Yoga for depression: A systematic review and meta-analysis	1
Cuijpers, P.	2009	Review: Exercise may moderately improve depressive symptoms	5
Dale, H.; Brassington, L.; King, K.	2014	The impact of healthy lifestyle interventions on mental health and wellbeing: A systematic review	1
Daley, A. J.; Foster, L.; Long, G.; Palmer, C.; Robinson, O.; Walmsley, H.; Ward, R.	2015	The effectiveness of exercise for the prevention and treatment of antenatal depression: Systematic review with meta-analysis	3
Daley, A. J.; MacArthur, C.; Winter, H.	2007	The role of exercise in treating postpartum depression: A review of the literature	5
Danielsson, L.; Noras, A. M.; Waern, M.; Carlsson, J.	2013	Exercise in the treatment of major depression: A systematic review grading the quality of evidence	1
Deligiannidis, K. M.; Freeman, M. P	2014	Complementary and alternative medicine therapies for perinatal depression	5
de Souza Moura, Antonio Marcos; Lamego, Murilo Khede; Paes, Flávia; Ferreira Rocha, Nuno Barbosa; Simoes-Silva, Vitor; Rocha, Susana Almeida; de Sá Filho, Alberto Souza; Rimes, Ridson; Manochio, João; Budde, Henning; Wegner, Mirko; Mura, Gioia; Arias-Carrión, Oscar; Yuan, Ti-Fei; Nardi, Antonio Egidio; Machado, Sergio	2015	Comparison among aerobic exercise and other types of interventions to treat Depression: A systematic review	5
Donaghy, Marie E.	2007	Exercise can seriously improve your mental health: Fact or fiction?	1
Ellis, N.; Crone, D.; Davey, R.; Grogan, S.	2007	Exercise interventions as an adjunct therapy for psychosis: A critical review	1
Fabricatore, A. N.; Wadden, T. A.; Higginbotham, A. J.; Faulconbridge, L. F.; Nguyen, A. M.; Heymsfield, S. B.; Faith, M. S.; Fabricatore, A. N.; Wadden, T. A.; Higginbotham, A. J.; Faulconbridge, L. F.; Nguyen, A. M.; Heymsfield, S. B.; Faith, M. S.	2011	Intentional weight loss and changes in symptoms of depression: A systematic review and meta-analysis	1
Firth, J.; Rosenbaum, S.; Stubbs, B.; Gorczynski, P.; Yung, A. R.; Vancampfort, D.	2016	Motivating factors and barriers towards exercise in severe mental illness: A systematic review and meta-analysis	8
Firth, J.; Stubbs, B.; Rosenbaum, S.; Vancampfort, D.; Malchow, B.; Schuch, F.; Elliott, R.; Nuechterlein, K. H.; Yung, A. R.	2017	Aerobic exercise improves cognitive functioning in people with schizophrenia: A systematic review and meta-analysis	8
Frazer, C. J.; Christensen, H.; Griffiths, K. M.	2005	Effectiveness of treatments for depression in older people	4
Gartlehner, G.; Gaynes, B. N.; Amick, H. R.; Asher, G. N.; Morgan, L. C.; Coker-Schwimmer, E.; Forneris, C.; Boland, E.; Lux, L. J.; Gaylord, S.; Bann, C.; Pierl, C. B.; Lohr, K. N.	2016	Comparative benefits and harms of antidepressant, psychological, complementary, and exercise treatments for major depression: An evidence report for a clinical practice guideline from the American College of Physicians	1
Gong, H.; Ni, C. X.; Shen, X. L.; Wu, T. Y.; Jiang, C. L.	2015	Yoga for prenatal depression: A systematic review and meta-analysis	1

Author	Year	Title	Reason
Gumarães, J. M. N.; Caldas, C. P.	2006	The influence of exercise on depressive disorders of the elderly: A systematic review	6
Kirkwood, G.; Rampes, H.; Tuffrey, V.; Richardson, J.; Pilkington, K.	2005	Yoga for anxiety: A systematic review of the research evidence	1
Farah, W. H.; Alsawas, M.; Mainou, M.; Alahdab, F.; Farah, M. H.; Ahmed, A. T.; Mohamed, E. A.; Almasri, J.; Gionfriddo, M. R.; Castaneda-Guarderas, A.; Mohammed, K.; Wang, Z.; Asi, N.; Sawchuk, C. N.; Williams, M. D.; Prokop, L. J.; Murad, M. H.; Leblanc, A.	2016	Non-pharmacological treatment of depression: A systematic review and evidence map	4
Farholm, A.; Sørensen, M.	2016	Motivation for physical activity and exercise in severe mental illness: A systematic review of cross-sectional studies	8
Faulkner, G.; Soundy, A. A.; Lloyd, K.	2003	Schizophrenia and weight management: A systematic review of interventions to control weight	4
Fernández-San-Martín, M. I.; Martín-López, L. M.; Masa-Font, R.; Olona-Tabueña, N.; Roman, Y.; Martin-Royo, J.; Oller-Canet, S.; González-Tejón, S.; San-Emeterio, L.; Barroso-Garcia, A.; Viñas-Cabrera, L.; Flores-Mateo, G.	2014	The effectiveness of lifestyle interventions to reduce cardiovascular risk in patients with severe mental disorders: Meta-analysis of intervention studies	4
Firth, Joseph; Cotter, Jack; Carney, Rebekah; Yung, Alison R.	2017	The pro-cognitive mechanisms of physical exercise in people with schizophrenia	8
Giesen, E. S.; Deimel, H.; Bloch, W	2015	Clinical exercise interventions in alcohol use disorders: A systematic review	1
Herring, M. P.; O'Connor, P. J.; Dishman, R. K.	2010	The effect of exercise training on anxiety symptoms among patients a systematic review	1
Hjorth, P.; Davidsen, A. S.; Kilian, R.; Skrubbeltrang, C.	2014	A systematic review of controlled interventions to reduce overweight and obesity in people with schizophrenia	4
Jorm, A. F.; Christensen, H.; Griffiths, K. M.; Parslow, R. A.; Rodgers, B.; Blewitt, K. A.	2004	Effectiveness of complementary and self-help treatments for anxiety disorders	4
Josefsson, T.; Lindwall, M.; Archer, T	2014	Physical exercise intervention in depressive disorders: Meta-analysis and systematic review	1
Knapen, Jan; Vancampfort, Davy; Moriën, Yves; Marchal, Yannick	2015	Exercise therapy improves both mental and physical health in patients with major depression	5
Kucyi, A.; Alsuwaidan, M. T.; Liauw, S. S.; McIntyre, R. S.	2010	Aerobic physical exercise as a possible treatment for neurocognitive dysfunction in bipolar disorder	5
Lawlor, D. A.; Hopker, S. W.	2001	The effectiveness of exercise as an intervention in the management of depression: Systematic review and meta-regression analysis of randomised controlled trials	1
Ledochowski, L.; Stark, R.; Ruedl, G.; Kopp, M.	2017	Körperliche Aktivität als therapeutische Intervention bei Depression (Physical activity as therapeutic intervention for depression)	6
Li, J.; Theng, Y. L.; Foo, S.	2016	Effect of exergames on depression: A systematic review and meta-analysis	1
Liu, X.; Clark, J.; Siskind, D.; Williams, G. M.; Byrne, G.; Yang, J. L.; Doi, S. A.	2015	A systematic review and meta-analysis of the effects of Qigong and Tai Chi for depressive symptoms	1

Author	Year	Title	Reason
Long, B. C.; Vanstavel, R.	1995	Effects of exercise training on anxiety: A meta analysis	1
Lowe, T.; Lubos, E.	2008	Effectiveness of weight management interventions for people with serious mental illness who receive treatment with atypical antipsychotic medications. A literature review	1
Mason, Oliver J.; Holt, Rebecca	2012	Mental health and physical activity interventions: A review of the qualitative literature	8
Melo, M. C. A.; Daher, E. D. F.; Albuquerque, S. G. C.; De Bruin, V. M. S.	2016	Exercise in bipolar patients: A systematic review	1
Morris, R. K.	2015	Re: The effectiveness of exercise for the prevention and treatment of antenatal depression: systematic review with meta-analysis; Association and prediction of amniotic fluid measurements for adverse pregnancy outcome: systematic review and meta-analysis; Does induction of labour increase the risk of caesarean section? A systematic review and meta analysis of trials in women with intact membranes Reply	5
Mura, G.; Carta, M. G	2013	Physical activity in depressed elderly. A systematic review	1
Mura, Gioia; Moro, Maria Francesca; Patten, Scott B.; Carta, Mauro G.	2014	Exercise as an add-on strategy for the treatment of major depressive disorder: A systematic review	1
Mura, G.; Sancassiani, F.; Machado, S.; Carta, M. G.	2014	Efficacy of exercise on depression: A systematic review	1
Oh, B.; Choi, S. M.; Inamori, A.; Rosenthal, D.; Yeung, A.	2013	Effects of qigong on depression: A systemic review	1
Papanastasiou, E.	2012	Interventions for the metabolic syndrome in schizophrenia: A review	4
Papasavvas, T.; Bonow, R. O.; Alhashemi, M.; Micklewright, D.	2016	Depression symptom severity and cardiorespiratory fitness in healthy and depressed adults: A systematic review and meta-analysis	1
Park, A. L.; McDaid, D.; Weiser, P.; Von Gottberg, C.; Becker, T.; Kilian, R.; Helps Network	2013	Examining the cost-effectiveness of interventions to promote the physical health of people with mental health problems: A systematic review	1
Park, S. H.; Han, K. S.; Kang, C. B.	2014	Effects of exercise programs on depressive symptoms, quality of life, and self-esteem in older people: A systematic review of randomized controlled trials	4
Padilla Moledo, Carmen; Coterón López, Javier	2013	¿Podemos mejorar nuestra salud mental a través de la Danza?: una revisión sistemática. / Can we improve mental health dancing?: A systematic review	6
Patiño Villada, Fredy Alonso; Arango Vélez, Elkin Fernando; Baena, Lucidia Zuleta	2013	[Physical Exercise and Depression in the Elderly: A Systematic Review]	6
Pearsall, R.; Smith, D. J.; Pelosi, A.; Geddes, J.	2014	Exercise therapy in adults with serious mental illness: A systematic review and meta-analysis	1
Pilkington, K.; Kirkwood, G.; Rampes, H.; Richardson, J.	2005	Yoga for depression: The research evidence	1
Poyatos-León, Raquel; García-Hermoso, Antonio; Sanabria-Martínez, Gema; Álvarez-Bueno, Celia; Cavero-Redondo, Iván; Martínez-Vizcaíno, Vicente	2017	Effects of exercise-based interventions on postpartum depression: A meta-analysis of randomized controlled trials	1
Olker, S. J.; Parrott, J. S.; Swarbrick, M. A.; Spagnolo, A. B.	2016	Weight management interventions in adults with a serious mental illness: A meta-analytic review	4

Author	Year	Title	Reason
Ramos, Sonia Iriarte; Torralba, María Victoria Pérez; Gómez, Ana Isabel Sanz; Alquézar, Ana Carmen Zaera; Bernardos, Marta Charlo	2011	Physical activity and mental health, an inseparable duet?	6
Ranjbar, Elaheh; Memari, Amir Hossein; Hafizi, Sina; Shayestehfar, Monir; Mirfazeli, Fatemeh Sadat; Eshghi, Mohammad Ali	2015	Depression and exercise: A clinical review and management guideline	5
Rhyner, K. T.; Watts, A.	2016	Exercise and depressive symptoms in older adults: A systematic meta-analytic review	1
Riahi, M. A.; Haddad, M.; Ouattas, A.; Goebel, R.; Grigore, V.; Stanescu, M.; Paunescu, M.	2016	The moderating effect of physical exercise in anxiety disorder: A review	5
Robertson, R.; Robertson, A.; Jepson, R.; Maxwell, M.	2012	Walking for depression or depressive symptoms: A systematic review and meta-analysis	1
Rosenbaum, Simon; Lederman, Oscar; Stubbs, Brendon; Vancampfort, Davy; Stanton, Robert; Ward, Philip B.	2016	How can we increase physical activity and exercise among youth experiencing first-episode psychosis? A systematic review of intervention variables	8
Saligheh, Maryam; Hackett, Daniel; Boyce, Philip; Cobley, Stephen	2017	Can exercise or physical activity help improve postnatal depression and weight loss? A systematic review	1
Sanada, K.; Zorrilla, I.; Iwata, Y.; Bermudez-Ampudia, C.; Graff-Guerrero, A.; Martinez-Cengotitabengoa, M.; Gonzalez-Pinto, A.	2016	The efficacy of non-pharmacological interventions on brain-derived neurotrophic factor in Schizophrenia: A systematic review and meta-analysis	4
Schuch, F. B.; Deslandes, A. C.; Stubbs, B.; Gosmann, N. P.; Silva, C. T. B. D.; Fleck, M. P. D. A	2016	Neurobiological effects of exercise on major depressive disorder: A systematic review	8
Sharma, Manoj; Haider, Taj	2013	Tai Chi as an alternative or complementary therapy for patients with depression: A systematic review	1
Asher, Gary N.; Gartlehner, Gerald; Gaynes, Bradley N.; Amick, Halle R.; Forneris, Catherine; Morgan, Laura C.; Coker-Schwimmer, Emmanuel; Boland, Erin; Lux, Linda J.; Gaylord, Susan; Bann, Carla; Pierl, Christiane Barbara; Lohr, Kathleen N.	2017	Comparative benefits and harms of complementary and alternative medicine therapies for initial treatment of Major Depressive Disorder: Systematic review and meta-analysis	4
Bandelow, B.; Reitt, M.; Röver, C.; Michaelis, S.; Görlich, Y.; Wedekind, D.	2015	Efficacy of treatments for anxiety disorders: A meta-analysis	1
Barton, J.; Pretty, J.	2010	What is the best dose of nature and green exercise for improving mental health- A multi-study analysis	5
Bauer, K.; Felder, H.	2008	[Sport therapy for depressive disorders: systematic review]	6
Brondino, N.; Rocchetti, M.; Fusar-Poli, L.; Codrons, E.; Correale, L.; Vandoni, M.; Barbui, C.; Politi, P.		A systematic review of cognitive effects of exercise in depression	8
Cooney, G. M.; Dwan, K.; Greig, C. A.; Lawlor, D. A.; Rimer, J.; Waugh, F. R.; McMurdo, M.; Mead, G. E.	2013	Exercise for depression	1

Author	Year	Title	Reason
de Souza Moura, Antonio Marcos; Lamego, Murilo Khede; Paes, Flávia; Ferreira Rocha, Nuno Barbosa; Simoes-Silva, Vitor; Rocha, Susana Almeida; de Sá Filho, Alberto Souza; Rimes, Ridson; Manochio, João; Budde, Henning; Wegner, Mirko; Mura, Gioia; Arias-Carrión, Oscar; Yuan, Ti-Fei; Nardi, Antonio Egidio; Machado, Sergio	2015	Effects of aerobic exercise on anxiety disorders: A systematic review	1
Gorczynski, Paul; Faulkner, Guy	2010	Exercise therapy for schizophrenia	1
Ledochowski, L.; Stark, R.; Ruedl, G.; Kopp, M.	2017	Physical activity as a therapeutic intervention for depression	6
Mead, G. E.; Morley, W.; Campbell, P.; Greig, C. A.; McMurdo, M.; Lawlor, D. A.	2008	Exercise for depression	1
Mead, G. E.; Morley, W.; Campbell, P.; Greig, C. A.; McMurdo, M.; Lawlor, D. A.	2009	Exercise for depression	1
Meekums, Bonnie; Karkou, Vicky; Nelson, E Andrea	2015	Dance movement therapy for depression	4
Rimer, J.; Dwan, K.; Lawlor, D. A.; Greig, C. A.; McMurdo, M.; Morley, W.; Mead, G. E.	2012	Exercise for depression	1
Rosenbaum, Simon; Sherrington, Catherine	2011	Is exercise effective in promoting mental well-being in older age? A systematic review	1
Silveira, H.; Moraes, H.; Oliveira, N.; Coutinho, E. S. F.; Laks, J.; Deslandes, A.	2013	Physical exercise and clinically depressed patients: A systematic review and meta-analysis	1
Soundy, A.; Freeman, P.; Stubbs, B.; Probst, M.; Coffee, P.; Vancampfort, D.	2014	The transcending benefits of physical activity for individuals with schizophrenia: A systematic review and meta-ethnography	8
Sharma, Manoj; Haider, Taj	2015	Tai chi as an alternative and complimentary therapy for anxiety: A systematic review	1
Shivakumar, G.; Brandon, A. R.; Snell, P. G.; Santiago-Munoz, P.; Johnson, N. L.; Trivedi, M. H.; Freeman, M. P.	2011	Antenatal depression: A rationale for studying exercise	1
Skowronek, I. B.; Mounsey, A.; Handler, L.	2014	Can yoga reduce symptoms of anxiety and depression?	5
Soundy, A.; Muhamed, A.; Stubbs, B.; Probst, M.; Vancampfort, D.	2014	The benefits of walking for individuals with schizophrenia spectrum disorders: A systematic review	2
Soundy, Andrew; Roskell, Carolyn; Stubbs, Brendon; Vancampfort, Davy	2014	Selection, use and psychometric properties of physical activity measures to assess individuals with Severe Mental Illness: A narrative synthesis	4
Stammes, R.; Spijker, J.	2009	Fysieke training bij depressie; een overzicht. = Physical training to treat depression	6
Stanton, Robert; Reaburn, Peter; Happell, Brenda	2013	Is cardiovascular or resistance exercise better to treat patients with depression? A narrative review	5
Stathopoulou, G.; Powers, M. B.; Berry, A. C.; Smits, J. A. J.; Otto, M. W.	2006	Exercise interventions for mental health: A quantitative and qualitative review	1
Steenhuis, L. A.; Nauta, M. H.; Bocking, C. L. H.; Pijnenborg, G. H. M.	2015	Treating depressive symptoms in Psychosis: A network meta-analysis on the effects of non-verbal therapies	1
Stich, Frederick Adams	1999	A meta-analysis of physical exercise as a treatment for symptoms of anxiety and depression	1
Stonerock, G. L.; Hoffman, B. M.; Smith, P. J.; Blumenthal, J. A.	2015	Exercise as treatment for anxiety: Systematic review and analysis	1
Stammes, R.; Spijker, J.	2009	Physical training to treat depression	6

Author	Year	Title	Reason
Takács, J.	2014	[Regular physical activity and mental health. The role of exercise in the prevention of, and intervention in depressive disorders]	6
Takács, Johanna; Stauder, Adrienne	2016	The role of regular physical activity in the prevention and intervention of symptoms of anxiety and anxiety disorders]	6
Torres, Elisa R.; Sampselle, Carolyn M.; Gretebeck, Kimberlee A.; Ronis, David L.; Neighbors, Harold W.	2010	Physical activity effects on depressive symptoms in black adults	1
Tsang, H. W. H.; Chan, E. R.; Cheung, W. M.	2008	Effects of mindful and non-mindful exercises on people with depression: A systematic review	1
van Hasselt, F. M.; Krabbe, P.; van Ittersum, D. G.; Postma, M. J.; Loonen, A. J. M.	2013	Evaluating interventions to improve somatic health in severe mental illness: A systematic review	1
Verhaeghe, N.; De Maeseneer, J.; Maes, L.; Van Heeringen, C.; Annemans, L.	2011	Effectiveness and cost-effectiveness of lifestyle interventions on physical activity and eating habits in persons with severe mental disorders: A systematic review	1
Wang, C. W.; Chan, C. L. W.; Ho, R. T. H.; Tsang, H. W. H.; Chan, C. H. Y.; Ng, S. M	2013	The effect of qigong on depressive and anxiety symptoms: A systematic review and meta-analysis of randomized controlled trials	1
Taylor, J.; Stubbs, B.; Hewitt, C.; Ajjan, R. A.; Alderson, S. L.; Gilbody, S.; Holt, R. I. G.; Hosali, P.; Hughes, T.; Kayalackakom, T.; Kellar, I.; Lewis, H.; Mahmoodi, N.; McDermid, K.; Smith, R. D.; Wright, J. M.; Siddiqi, N.	2017	The effectiveness of pharmacological and non-pharmacological interventions for improving glycaemic control in adults with severe mental illness: A systematic review and meta-analysis	3
Vancampfort, Davy; Probst, Michel; Helvik Skjaerven, Liv; Catalán-Matamoros, Daniel; Lundvik-Gyllensten, Amanda; Gómez-Conesa, Antonia; Ijntema, Rutger; De Hert, Marc	2012	Systematic review of the benefits of physical therapy within a multidisciplinary care approach for people with schizophrenia	1
Vancampfort, D.; Firth, J.; Schuch, F.; Rosenbaum, S.; De Hert, M.; Mugisha, J.; Probst, M.; Stubbs, B.	2016	Physical activity and sedentary behavior in people with bipolar disorder: A systematic review and meta-analysis	8
Vancampfort, D.; Knapen, J.; De Hert, M.; van Winkel, R.; Deckx, S.; Maurissen, K.; Peuskens, J.; Simons, J.; Probst, M.	2009	Cardiometabolic effects of physical activity interventions for people with schizophrenia	2
Vancampfort, D.; Knapen, J.; Probst, M.; Scheewe, T.; Remans, S.; De Hert, M.	2012	A systematic review of correlates of physical activity in patients with schizophrenia	8
Vancampfort, D.; Probst, M.; De Hert, M.; Soundy, A.; Stubbs, B.; Stroobants, M.; De Herdt, A.	2014	Neurobiological effects of physical exercise in schizophrenia: A systematic review	8
Vancampfort, D.; Richards, J.; Stubbs, B.; Akello, G.; Gbiri, C. A.; Ward, P. B.; Rosenbaum, S.	2016	Physical activity in people with posttraumatic stress disorder: A systematic review of correlates	8
Vancampfort	2016	Prevalence and predictors of treatment dropout from physical activity interventions in schizophrenia: A meta-analysis	8
Vancampfort, D.; Stubbs, B.; De Hert, M.; du Plessis, C.; Gbiri, C. A. O.; Kibet, J.; Wanyonyi, N.; Mugisha, J.	2017	A systematic review of physical activity policy recommendations and interventions for people with mental health problems in Sub-Saharan African countries	1
Wang, Y. Y.; Chang, H. Y.; Lin, C. Y.	2014	Systematic review of yoga for depression and quality of sleep in the elderly	6

Author	Year	Title	Reason
Wegner, M.; Helmich, I.; Machado, S.; Nardi, A. E.; Arias-Carrión, O.; Budde, H.	2014	Effects of exercise on anxiety and depression disorders: Review of meta-analyses and neurobiological mechanisms	1
Whitworth, James W.; Ciccolo, Joseph T.	2016	Exercise and post-traumatic stress disorder in military veterans: A systematic review	1
Wipfli, B. M.; Rethorst, C. D.; Landers, D. M.	2008	The anxiolytic effects of exercise: A meta-analysis of randomized trials and dose-response analysis	1
Wolf, S.; Hautzinger, M.	2012	Alleviation of depressive symptomatology. Is sport activity a recommendable therapeutic method?	6
Wright, Kim A.; Everson-Hock, E. S.; Taylor, A. H.	2009	The effects of physical activity on physical and mental health among individuals with bipolar disorder: A systematic review	1
Yin, J. C.; Dishman, R. K.	2014	The effect of Tai Chi and Qigong practice on depression and anxiety symptoms: A systematic review and meta-regression analysis of randomized controlled trials	1
Zschucke, E.; Heinz, A.; Strhle, A.	2012	Exercise and physical activity in the therapy of substance use disorders	1
Vogel, J. S.; Van der Gaag, M.; Knegtering, H.; Castelein, S.	2015	Effects of aerobic exercise on negative symptoms in schizophrenia: A meta-analysis	
Schuch, F. B.; Vasconcelos-Moreno, M. P.; Fleck, M. P.	2012	The impact of exercise on quality of life within exercise and depression trials: A systematic review': Corrigendum	5
Schuch, F. B.; Vasconcelos-Moreno, M. P.; Fleck, M. P.	2012	The impact of exercise on quality of life within exercise and depression trials: A systematic review	1
Schuch, F.; Vancampfort, D.; Firth, J.; Rosenbaum, S.; Ward, P.; Reichert, T.; Bagatini, N. C.; Bgeginski, R.; Stubbs, B.	2017	Physical activity and sedentary behavior in people with major depressive disorder: A systematic review and meta-analysis	8
Soundy, A.; Wampers, M.; Probst, M.; Hert, M. D.; Stubbs, B.; Vancampfort, D.	2013	Physical activity and sedentary behaviour in outpatients with schizophrenia: A systematic review and meta-analysis	8
Stanton, Robert; Happell, Brenda	2014	A systematic review of the aerobic exercise program variables for people with schizophrenia	8
Stanton, R.; Reaburn, P.	2014	Exercise and the treatment of depression: A review of the exercise program variables	8
Stubbs, B.; Firth, J.; Berry, A.; Schuch, F. B.; Rosenbaum, S.; Gaughran, F.; Veronesse, N.; Williams, J.; Craig, T.; Yung, A. R.; Vancampfort, D.	2016	How much physical activity do people with schizophrenia engage in? A systematic review, comparative meta-analysis and meta-regression	8
Stubbs, B.; Rosenbaum, S.; Ward, P. B.; Schuch, F. B.; Vancampfort, D.	2015	No evidence of a control group response in exercise randomised controlled trials in people with schizophrenia: A systematic review and meta-analysis	8
Stubbs, Brendon; Vancampfort, Davy; Rosenbaum, Simon; Ward, Philip; Richards, Justin; Ussher, Michael; Schuch, Felipe	2016	Challenges establishing the efficacy of exercise as an antidepressant treatment: A systematic review and meta-analysis of control group responses in exercise randomised controlled trials	8
Stubbs, B.; Williams, J.; Gaughran, F.; Craig, T.	2016	How sedentary are people with psychosis? A systematic review and meta-analysis	8
Stubbs, B.; Vancampfort, D.; Rosenbaum, S.; Ward, P. B.; Richards, J.; Soundy, A.; Veronese, N.; Solmi, M.; Schuch, F. B.	2016	Dropout from exercise randomized controlled trials among people with depression: A meta-analysis and meta regression	8

Author	Year	Title	Reason
Vancampfort, D.; Correll, C. U.; Probst, M.; Sienaert, P.; Wyckaert, S.; De Herdt, A.; Knapen, J.; De Wachter, D.; De Hert, M.	2013	A review of physical activity correlates in patients with bipolar disorder	8
Vancampfort, Davy; Stubbs, Brendon; Sienaert, Pascal; Wyckaert, Sabine; De Hert, Marc; Rosenbaum, Simon; Probst, Michel	2015	What are the factors that influence physical activity participation in individuals with depression? A review of physical activity correlates from 59 studies	8
Wang, Fang; Lee, Eun-Kyoung Othelia; Wu, Taixiang; Benson, Herbert; Fricchione, Gregory; Wang, Weidong; Yeung, Albert S.	2014	The effects of tai chi on depression, anxiety, and psychological well-being: A systematic review and meta-analysis	1
Gartlehner, G.; Wagner, G.; Matyas, N.; Titscher, V.; Greimel, J.; Lux, L.; Gaynes, B. N.; Viswanathan, M.; Patel, S.; Lohr, K. N.	2017	Pharmacological and non-pharmacological treatments for major depressive disorder: Review of systematic reviews	4
Daley	2008	Exercise and depression: A review of reviews	1
Antoniades, J.; Mazza, D.; Brijnath, B.	2014	Efficacy of depression treatments for immigrant patients: Results from a systematic review	4
Bridle, C.; Spanjers, K.; Patel, S.; Atherton, N. M.; Lamb, S. E.	2012	Effect of exercise on depression severity in older people systematic review and meta-analysis of randomised controlled trials	1
Wang Cong-Jiang	2014	Meta Analysis on effects of physical exercise on the depressive symptoms of college students in China	6
Sjösten, N.; Kivelä, S. L.	2006	The effects of physical exercise on depressive symptoms among the aged: A systematic review	1
North, T. C.; McCullagh, P.; Tran, Z. V.; Lavallee, David; Williams, Jean M.; Jones, Marc V.; Papathomas, Anthony; Lavallee, David; Williams, Jean M.; Jones, Marc V.; Lavallee, David; Williams, Jean M.; Jones, Marc V.	2008	Effect of exercise on depression	NA
Catalan-Matamoros, D.; Gomez-Conesa, A.; Stubbs, B.; Vancampfort, D.	2016	Exercise improves depressive symptoms in older adults: An umbrella review of systematic reviews and meta-analyses	5
McCurdy, A. P.; Boulé, N. G.; Sivak, A.; Davenport, M. H.	2017	Effects of exercise on mild-to-moderate depressive symptoms in the postpartum period: A meta-analysis	1
Cipriani	2011	Depression in adults: Drug and physical treatments	5
Leigh-Hunt, N.; Perry, A.	2015	A systematic review of interventions for anxiety, depression, and PTSD in adult offenders	4
Holley, Jessica; Crone, Diane; Tyson, Philip; Lovell, Geoff	2011	The effects of physical activity on psychological well-being for those with schizophrenia: A systematic review	2
Vancampfort, Davy; Correll, Christoph U.; Scheewe, Thomas W.; Probst, Michel; De Herdt, Amber; Knapen, Jan; De Hert, Marc	2013	Progressive muscle relaxation in persons with schizophrenia: a systematic review of randomized controlled trials	4
Das, C.; Mendez, G.; Jagasia, S.; Labbate, L. A.	2012	Second-generation antipsychotic use in schizophrenia and associated weight gain: A critical review and meta-analysis of behavioral and pharmacologic treatments	4

Author	**Year**	**Title**	**Reason**
Falkai, P.; Malchow, B.; Schmitt, A.	2017	Aerobic exercise and its effects on cognition in schizophrenia	5
Uebelacker, L. A.; Epstein-Lubow, G.; Gaudiano, B. A.; Tremont, G.; Battle, C. L.; Miller, I. W.	2010	Hatha yoga for depression: Critical review of the evidence for efficacy, plausible mechanisms of action, and directions for future research	5
Shi, Y. A. N.; YinZhe, J. I. N.; YongSeok, O. H.; YoungJun, Choi	2016	Effect of exercise on depression in university students: A meta-analysis of randomized controlled trials	1
Wang, X.	2005	Association between exercise therapy and depression	6
Dong, B.; He, P.; Lu, Z.; Wu, T.; Liu, G.; Huang, C. C.	2008	Exercise for older depressed people	NA
North, T. C.	1989	The effect of exercise on depression: A meta-analysis	NA
Rethorst, C. D.; Wipfli, B. M.; Landers, D. M.	2009	The antidepressive effects of exercise: A meta-analysis of randomized trials	NA
Perraton, L. G.; Kumar, S.; Machotka, Z.	2010	Exercise parameters in the treatment of clinical depression: A systematic review of randomized controlled trials	8
Schuch, F. B.; Dunn, A. L.; Kanitz, A. C.; Delevatti, R. S.; Fleck, M. P.	2016	Moderators of response in exercise treatment for depression: A systematic review	8
Vancampfort, Davy; Stubbs, Brendon; Richards, Justin; Ward, Philip B.; Firth, Joseph; Schuch, Felipe B.; Rosenbaum, Simon	2016	Physical fitness in people with posttraumatic stress disorder: A systematic review	8

Supplemental Table 5: Characteristics of included studies

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
Depression							
Blake, 2009	MEDLINE, Embase, CINAHL, PsycINFO, The Cochrane Library (Issue 2, 2008) and National Research Register (NRR; Issue 2, 2008). Search terms provided.	May 2008	11 (n=641)	Depression or dysthymia according to DSM-IV, or were screened for depressive symptoms using standardized measurement.	Physical activity interventions (i.e., walking, aerobics, tai chi, qigong and weight-bearing or progressive resistance training). Various intensities and duration (common 3 times per week for between 20-60 minutes) and intervention length (6 to 19 weeks).	Any comparison (i.e., medication, usual care, health education, social, information about exercise, newspaper reading).	Efficacy of physical exercise interventions for reducing depressive symptoms in older people (aged > 60 years).
Cramer, 2017	PRISMA, Medline/PubMed, Scopus, and the Cochrane Central Register of Controlled Trials (Central). Search terms provided.	6 December 2016	8 (n=240)	Major depressive disorder according to DSM-IV or DSM-V. Or ≥75% diagnosed with major depressive disorder and the remaining participants with other depressive disorders.	Sudarshan kriya yoga, hatha yoga, lifeforce yoga program, sahaj yoga meditation, prenatal yoga program. Duration of intervention: 1 - 6 times per week (median 2 times per week) of 30 to 210 min (median 75 min) per session. Contact time with therapist: 120 and 1890 minutes (median 675 minutes).	No specific treatment, pharmacological or non-pharmacological interventions.	Efficacy and safety of yoga to treat major depressive disorder (depressive symptom reduction).
Eriksson, 2011	PsycINFO, PsycARTICLES, PsycCRITI QUES and PubMed. Search terms provided.	2000-2010	8 (n=747)	Depression diagnosed according to DSM-IV, ICD-10 and/or scales of depression	Exercise intervention (i.e., muscle and aerobic strength in a group setting, progressive resistance training, aerobic). Duration of intervention: 10 days - 5 months. Supervised and unsupervised.	Any comparison (i.e., placebo, relaxation, flexibility, health education, general practice care).	Review type of exercise and treatment outcomes (depressive symptoms change) for exercise as a treatment for major depression.

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
Heinzel, 2015	PubMed, The Cochrane Central Registry of Controlled Trials, Embase, PsychINFO and Web of Science. Search terms provided.	March 2015	18 (n=1091)	Valid measurement or diagnosis of Major depressive disorder according to DSM-IV-TR.	Exercise interventions (i.e., aerobic and resistance programs and alternative exercise programs, such as tai chi and qi gong).	Any comparison (i.e., anti-depressant, usual care, waitlist, social visit, health education, usual medical care, sedentary or newspaper reading).	Effects of exercise on depressive symptoms in older adults.
Kvam, 2016	SportsDiscus, PsycINFO, Medline, Embase, and Cochrane Central Register of Controlled Trials (CENTRAL). Search terms provided.	For SportsDiscus January 2007-24 November 2014. All other January 2010 to 20 November 2014	23 (n=977)	Diagnosis of Unipolar depression according to DSM- or ICD criteria. Some studies had a small number of participants diagnosed with minor depression or dysthymia.	Aerobic (i.e., walking, running or cycling) and non-aerobic exercise (i.e., resistance exercise, strength exercise or weightlifting), including those in combination with other anti-depressant treatments. Not studies with tai chi, qigong, yoga.	Any comparison (i.e., placebo treatment, usual care, another kind of treatment (i.e., antidepressant medication, psychotherapy or alternative interventions), no treatment or wait-list).	Effect of exercise to reduce depressive symptoms compared to: 1) active control conditions (i.e., psychological treatments and anti-depressant medication), usual care and no intervention; 2) as an adjunct to treatment with antidepressant medication.
Krogh, 2011	Medline, Embase, PsychINFO, CINAHL, Cochrane control trial register, Cochrane data-base systematic review. Search terms provided	2008	13 (n=687)	Diagnosis of Depression according to ICD-10/RDC.	9 studies = aerobic exercise, 3 studies = anaerobic exercise, 1 study = mixed exercise protocol. Frequency: approximately 3 times per week for 10 weeks. 9=group, 4=individual.	No treatment, waitlist, placebo, established treatment.	Effect of exercise on depressive symptoms in adults with depression in a clinical setting.

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
Schuch, 2016(a)	PRISMA statement and the MOOSE guidelines. Academic Search Premier, Medline, Psychology and Behavioural Sciences Collection, PsycINFO, SPORTDiscus, CINAHL Plus and PubMed, Cochrane review on exercise for depression. Search terms provided.	January 2013 until 1 August 2015	25 (n=1487)	Diagnosis of Major depressive disorder according to RDC, DSM-IV or ICD-10, or validated screening measure.	Exercise as defined by Caspersen et al (1985). Length of intervention: 3 -32 weeks. Excluded tai chi, yoga or qi qoing. Supervised (qualified exercise professional) and unsupervised, group and individual interventions, aerobic and resistance and a combination of both, various intensities (light to vigorous).	Non-active control (i.e., usual-care, wait-list control conditions, placebo pills or other social activities).	Effects of exercise on depressive symptoms compared to: 1) non-active control (including sub-group analysis); and 2) the influence of publication bias on intervention effect.
Sukhato, 2017	Medline, Scopus and CINAHL. Search terms provided.	7 August 2016	17	Diagnosis of Depressive disorder according to DSM-IV, or any depression diagnostic tool.	Home-based non-pharmacological intervention (i.e., management of depression provided at patient's residence by healthcare professionals). The home-based exercise program included aerobic and resistance training of moderate intensity for 30 minutes, 3 times per week.	Care of depression in outpatient clinics or hospital settings.	Comparing the efficacy of home-based, non-pharmacological interventions on: 1) the severity of depressive symptoms; or 2) the incidence of disease remission.
Schuch, 2016(b)	PRISMA statement and MOOSE guidelines. Articles identified by a recent Cochrane review on exercise for depression that evaluated quality of life as an outcome. Academic Search Premier, MEDLINE, Psychology and Behavioural Sciences Collection, PsycINFO, SPORTDiscus, CINAHL Plus and	January 2013 to 1 August 2015	6 (n=198)	Diagnosis of Major depressive disorder (or dysthymia) according to DSM or ICD or validated screening measure.	Exercise as defined by Caspersen et al (1985). Length of intervention: 3 -32 weeks, completed between 2-5 times per week. Excluded tai chi, yoga or qi qoing.	Non-active control (i.e., usual-care/usual treatment, wait-list control conditions, placebo pills or other social activities).	Assess the effectiveness of exercise on quality of life and if a control group response occurs in relation to quality-of-life domains.

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
	PubMed. Search terms provided.						
Schuch, 2016(c)	PRISMA statement and the MOOSE guidelines. Articles identified in recent Cochrane review on exercise for depression. Academic Search Premier, Medline, Psychology and Behavioural Sciences Collection, PsycINFO, SPORTDiscus, CINHAL Plus, and PubMed databases. Search terms provided.	January 2013 until August 1, 2015	8	Diagnosis of Major depressive disorder (dysthymia), according to DSM or ICD or validated screening measure	Exercise as defined by Caspersen et al. (1985). Length of intervention: 6 -16 weeks. Excluded Tai Chi, yoga or qi qoing Supervised (qualified exercise professional)/ unsupervised, group/ individual, aerobic/resistance and a combination, mod/high intensity	Non-active control group (i.e., usual care/usual treatment, wait-list control conditions, placebo pills or other social activities).	Effect of exercise on depressive symptoms in older people: 1) comparing exercise vs. non-active control groups; 2) identify moderators that may influence exercise effects; 3) assess the influence of publication bias
Stubbs, 2016	MOOSE guidelines and PRISMA statement. Published Cochrane review and Academic Search Premier, Medline, Psychology and Behavioural Sciences Collection, PsycINFO, SPORTDiscus, CINAHL Plus and PubMed. Search terms provided.	January 2013 until August 1, 2015	7 (n=293)	Diagnosis of Major depressive disorder according to DSM-IV or validated screening measure.	Exercise as defined by Caspersen et al (1985). Duration of intervention: average 12 weeks.	Not applicable.	Analyse cardio-respiratory fitness changes with exercise interventions in people with depression, compared to control conditions.
Schizophrenia							

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
Dauwan, 2016	PRISMA statement; PubMed (Medline), Embase, PsychINFO and Cochrane Database of Systematic Reviews. Search terms provided.	31 July 2015	29 (n=1109)	Schizophrenia or Schizophrenia spectrum disorder according to DSM-III, DSM-III-R, DSM-IV, DSM-IV-TR or the ICD.	Duration of intervention: 3 weeks - 8 months Exercise volume: 16 - 720 mins per week Modality: mixed modalities.	Control conditions both active (i.e., table football, computer games or occupational therapy) or passive (i.e., waitlist, TAU).	The effects of exercise on: 1) clinical symptoms; 2) quality of life, global functioning, depression and cognition.
Keller-Varady, 2017	PubMed database and Cochrane Central Register of Controlled Trials. Search terms provided.	9 August 2016	6 (n=187)	Schizophrenia diagnosis according to the ICD-10 and the DSM-IV or DSM-V.	Various types of exercise. Duration/frequency/intensity of intervention: varied across studies. Modality: resistance training or resistance and aerobic exercises	Any comparison (i.e., computer games, occupational therapy, stretch, dance or usual care).	1) Benefits derived from strength training alone for patients with schizophrenia; 2) Identify if the combination of aerobic exercise and strength training is preferable to a single modality.
Firth, 2015	Ovid MEDLINE, Embase, PsycINFO and the Cochrane Central Register of Controlled Trials (CENTRAL). Search terms provided.	1 November 2013 (updated search on 6 April 2014)	17 (n=659)	Non-affective psychotic disorder (studies after 2014 when DSM and ICD were introduced).	Exercise as defined by Caspersen et al (1985), including physical activity interventions that matched this description. Not yoga, muscular relaxation, or adventure activities.	Any comparison, including active controls.	Summarise all exercise trials in schizophrenia and quantify effects on both physical and mental health outcomes.
Martin, 2017	PRISMA statement. AusportMed, AMED, Medline, Physiotherapy Evidence Database (PEDro), Canal, NICAN, Scopus, Web of Science and ScienceDirect. Search terms provided.	1 September 2016	7 (n=389)	Confirmed schizophrenia diagnosis (i.e., DSM-IV or DSMV).	Exercise interventions where interventions were $\geq$ 12 weeks (mean length = 18 weeks). The duration of aerobic exercise ranged from 20 to 60 min and resistance training volume varied.	Any comparison (i.e., TAU, active control, occupational therapy, or not reported).	The effect of exercise on changes to mental health variables, cardiovascular fitness and muscular strength.

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
Vancampfort, 2015	Embase, PubMed, CINAHL, PsycARTICLES, PEDro, and SPORTDiscus. Embase, PubMed, CINAHL, PsycARTICLES, PEDro, and SPORTDiscus. Search terms provided.	1 November 2014	11 (n=377)	First episode or chronic schizophrenia (spectrum) diagnosed according to ICD-10 or DSM-IV(V).	Duration of intervention: 6 weeks to 6 months Intensity: ranges from moderate to high Modality: graded aerobic exercise and/or resistance training.	Age/gender-matched control.	Cardio-respiratory fitness in this population.
Vancampfort, 2015 (a)	Medline, PsycARTICLES, Embase and CINAHL. Search terms provided.	May 2015	7 (n=77)	Schizophrenia spectrum disorder according to DSM or ICD.	Aerobic exercise interventions as defined by Caspersen et al (1985). Duration of intervention: ranged from 12 weeks to 6 months Frequency: ranges from 2 times per week to 3 times per week.	Non-aerobic interventions, usual-care or wait-list control.	Measure the effects of exercise interventions on Cardio-respiratory fitness and compare this effect with control interventions.
Vancampfort, 2012	PRISMA statement. Embase, PsycINFO, PubMed, ISI Web of Science, CINAHL, PEDro and Cochrane Library.	12 October 2011	3 (n=125)	Schizophrenia diagnosis according to DSM-IV.	Yoga defined as a practice of gentle stretching and exercises for breath control.	Any comparison (i.e., waitlist, active control (walking or/jogging).	The effectiveness of yoga interventions on: 1) general psychopathology; 2) positive and negative symptoms of schizophrenia; 3) health-related quality of life.
Zheng, 2016	PubMed, PsycINFO, Embase, Cochrane Library databases, the Cochrane Controlled Trials Register and Chinese databases (WanFang Database, Chinese Biomedical database and China Journal Net). Search terms provided.	27 August 2016	6 (n=483)	Schizophrenia according to DSM-IV, ICD-10 and CCMD-3.	Tai chi. The duration of intervention: ranged from 12 to 24 weeks Frequency: ranges from 30-60 minutes, once per week to daily.	Any comparison (i.e., yoga, waitlist, and usual daily activities).	Effects of tai chi on changes in positive or negative symptoms of schizophrenia.

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
Vera-Garcia, 2015	PRISMA guidelines. PROSPERO registered protocol. PubMed, PsycINFO, Embase, Web of Science, PEDro, and the Cochrane Library. Search terms provided.	July 1, 2011 to October 1, 2014	13 (n=549)	Schizophrenia spectrum disorders according to DSM-IV or ICD-10.	Physical exercise (i.e., aerobic exercises, strength exercises, relaxation training, basic body awareness exercises or a combination of these).	Usual care, wait-list, or intervention in healthy controls (provided the comparison interventions had similar durations).	Effectiveness of physical therapy interventions in the multidisciplinary management of schizophrenia (changes to positive and negative symptoms of schizophrenia).
Soundy, 2015	PRISMA statement and Cochrane review procedures. Amed, PubMed, SportsDiscus, CINAHL plus, and the Cochrane Library, Google Scholar and ScienceDirect. Search terms provided.	NA	10 (n=185)	> 85% of patients with Schizophrenia spectrum disorder according to DSM or ICD. Or where data from individuals with schizophrenia could be extracted from patients with other diagnoses.	An intervention or experience identified as a 'sport'.	Any comparison (i.e., control, alternative form of physical activity).	Sport participation effects on: 1) weight or body mass index and psychiatric symptoms; 2) influence on other health parameters.
Multiple mental health diagnoses							
Rosenbaum, 2014	Registered with PROSPERO, PRISMA statement. Medline, Embase, Cochrane Central Register of Clinical Trials, PsycINFO, CINHAL, and the PEDro Database. Search terms provided.	January 2013	39 (n=2008)	Diagnosis of psychiatric illness according to DSM-IV-Tr, ICD-10, or clinician-confirmed diagnosis of mental illness other than dysthymia or eating disorder.	All forms of physical activity and exercise that met the American College of Sports Medicine definitions.	Usual care, social, wait-list, placebo, aesthetic control or health education.	Effect of physical activity on: 1) depressive symptoms; 2) symptoms of schizophrenia in people with a mental illness; 3) anthropometric measurements, aerobic capacity, and self-reported quality of life.

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
Klatte, 2016	Registered with PROSPERO. PubMed, Web of Science, PsycINFO, ProQuest, GoogleScholar. Search terms provided.	21 November 2014	25 (n=1339)	Diagnosis of a mental disorder according to ICD or DSM.	Hatha yoga or yoga with asanas and pranayama as obligatory components. The duration of intervention: 2 to 24 weeks of between 5 to 100 hours (median=15 hours). Group classes with 3 to 25 participants (median =11).	Untreated control (i.e., no intervention other than basic treatment), active control (i.e., exercise, attentional control or psychotherapeutic + basic treatment).	Effect of yoga on symptoms of general psychopathology, depression, anxiety, stress, health-related functioning, quality of life or wellbeing.
Rosenbaum, 2015(a)	Registered with the PROSPERO. PRISMA statement. MEDLINE, PsycInfo, Cochrane Central Register of Clinical Trials, and Google Scholar. Search terms provided.	January 2015	2 (n=95)	Diagnosis of mental disorder according to DSM or ICD and/or receiving treatment from a specialist mental health service.	Online physical activity programmes.	Usual care, wait-list or no-treatment control group.	Effect of online physical activity interventions on 1) symptoms of mental illness and 2) changes in anthropometry outcome measures.
Vancampfort, 2017	MOOSE guidelines and the PRISMA statement. PubMed, Embase and CINAHL. Search terms provided.	31 December 2015	NA	Diagnosis of Schizophrenia spectrum, Major depressive disorder, or Bipolar disorder according to the DSM or ICD.	Aerobic exercise interventions.	All non-aerobic interventions (i.e., resistance or strength training), usual-care, or wait-list control conditions.	Cardio-respiratory fitness in people with serious mental illness versus healthy controls and investigate moderators of cardiorespiratory fitness. Effect of exercise on cardio-respiratory fitness and body mass index/waist circumference.
Stanton, 2016	PubMed, CINAHL, SPORTDiscus, PsychARTICLES, and PsychINFO. Search terms provided.	NA	8 studies	Diagnosed with Depression, Schizophrenia, Bipolar disorder, or Anxiety disorders, as defined by the DSM-IV, ICD-10, or	Aerobic or non-aerobic exercise training programme or a combination of both. Any duration or frequency.	Any comparison (i.e., pharmacotherapy, education, psychotherapy, other exercise programs or no intervention,	Examine the effects (i.e., change in mental health symptoms, quality of life or safety) of exercise on people with depression,

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
				validated diagnostic criteria.		including wait-list controls).	schizophrenia, bipolar disorder, or anxiety disorders in an inpatient setting.
Anxiety							
Bartley, 2013	PubMed and PsycINFO. Search terms provided.	January 2013	7 (n=407)	Anxiety disorders (as defined by DSM criteria, excluding PTSD).	6 studies = walking or jogging; 1 study = gym membership.	Any comparison (i.e., waitlist, placebo, cognitive behaviour therapy, psychoeducation, non-aerobic exercise, medication or other (includes active comparison)).	The effect of exercise on the mean improvement in anxiety score according to the primary rating scale used to measure anxiety.
Jayakody, 2014	Medline, Embase, PsycINFO, CINAHL, AMED and Cochrane database of systematic reviews. Hand search of selected peer-reviewed journals. Search terms provided.	July 2011	8 (n=563)	Anxiety disorders as diagnosed by: ICD, DSM, diagnostic tools/questionnaires, RDC, other validated criteria.	4 studies = aerobic exercise, waking, running 4 studies = mixed modalities	No exercise, placebo pill or anti-depressant medication.	Treatment effects of exercise compared with other treatments for anxiety disorders.
Stubbs, 2017	PRISMA and MOOSE statement; Academic Search Premier, Medline, Psychology and Behavioural Sciences Collection, PsycINFO, SPORTDiscus, CINAHL Plus and PubMed. Search terms provided.	15 Dec 2015	6 (n=262)	Anxiety or stress disorder (including PTSD) according to established criteria (i.e., RDC, DSM-IV).	Exercise as defined by Caspersen et al (1985). Trials that used yoga, tai chi or qigong, were excluded.	Control conditions (i.e., TAU or waitlist).	The effect of exercise on the mean change in anxiety score according to validated outcome measure.
Post-traumatic stress disorder (PTSD)							

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
Rosenbaum, 2015	MOOSE guidelines, PRISMA statement. Medline, PsycARTICLES, Embase and CINAHL. Search terms provided.	1 March 2015	4 (n=200)	Current or sub-threshold diagnosis of primary PTSD as per DSM or the ICD.	2 times yoga interventions, 1 time combined aerobic and resistance-based intervention, 1 time aerobic (stationary cycling) intervention.	Usual care or wait-list control.	Effect of physical activity interventions on: 1) PTSD symptoms; 2) other important functional and psychological outcomes (i.e., depression, sleep behaviour and cardiovascular risk).
Lawrence, 2010	The Cochrane Collaboration Depression, Anxiety and Neurosis Controlled Trials Registers, Cochrane Central registry of Controlled Trials, MEDLINE, EmbaseE, CINAHL, PsycINFO. Search terms provided.	June 2008	0	Diagnosed with PTSD according to DSM IV and ICD.	Sports and games including any type of recreational activity (i.e., athletics, yoga, and non-physical activities (computer games)).	Not applicable.	Effectiveness of 1) sports, and games in reducing symptoms of PTSD 2) the effect of different types of sports and games in reducing symptoms of PTSD.
Substance Use Disorder (SUD)/Alcohol use disorders (AUD)							
Hallgren, 2017	Moose guidelines and PRISMA statement. Medline, PsycARTICLES and Embase. Search terms provided.	11 April 2016	21 (n=1202)	AUDs diagnosed from DSM-I, DSM-II, DSM-III-R, DSM-IV, DSM 5, ICD-10, the Alcohol Use Disorders Identification Test (AUDIT), and guidelines from the National Institute on Alcohol Abuse and Alcoholism (NIAAA).	Exercise defined as planned, repetitive movement, purposefully engaged in to improve fitness and/or health. Duration of intervention: >2 weeks.	Active (i.e., cognitive behaviour therapy, group counselling or psychotherapy) and passive control groups (i.e., TAU, waitlist), 3 studies did not report a control group.	Alcohol consumption, the AUDIT score and alcohol urges/ cravings. Other outcomes included; physical activity, fitness, depression, anxiety, self-efficacy, quality of life and cortisol levels.

Review	Search strategy	Date assessed up to	Number of studies included in review	Population	Interventions	Comparison interventions	Outcomes for which data were reported
Wang, 2014	PRISMA guidelines. PubMed, Web of Science, Elsevier, China National Knowledge Infrastructure (CNKI), and China Info.	January 1990 to August 2013	22	Alcohol, nicotine, and illicit drug abusers through the DSM-III(R)/IV.	Chronic physical exercise. Mixed exercise modalities including aerobic exercise, mind body exercise (i.e., qigong or yoga) and strength training.	Types of control group unspecified.	Rate of abstinence from drug addiction, withdrawal symptoms, the level of depression and anxiety.
RCD = Research Diagnostic Criteria, DSM = Diagnostic and Statistical Manual of Mental Disorders, PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses, ICD = International Classification of Disease, MOOSE = Meta-analysis Of Observational Studies in Epidemiology, TAU = Treatment as Usual; Caspersen et al (1985) definition of exercise = planned physical activity with bodily movements that are structured and repetitive, performed for the purpose of improving or maintaining physical fitness (59)							

Supplemental Table 6: Participant numbers and primary outcomes

	Symptoms of mental illness	**Quality of Life**	**Physical health metric**	**Adverse events**	**Cost**
Interventions for Depression					
11 reviews (n=unknown)	9 reviews	1 review	1 review	3 reviews	0 reviews
Interventions for Schizophrenia					
10 reviews (n=4140)	8 reviews	5 reviews	5 reviews	5 reviews	0 reviews
Interventions for multiple mental health diagnosis					
5 reviews (n=unknown)	4 reviews	2 reviews	2 reviews	1 review	0 reviews
Interventions for Anxiety					
3 reviews (n=1232)	3 reviews	1 review	0 reviews	I review	0 reviews
Interventions for PTSD*					
2 reviews (n=392)	1 review	0 reviews	1 review	1 review	0 reviews
Interventions for SUD/AUD					
2 reviews (n=unknown)	2 reviews	0 reviews	1 review	1 review	0 reviews

* 1 review did not identify any studies that met their inclusion criteria
PTSD = Post-traumatic stress disorder
SUD/AUD = Substance use disorder/Alcohol use disorder

Chapter 4: **Czosnek L**, Richards J, Zopf E, Cormie P, Rosenbaum S, Rankin N. Exercise interventions for people diagnosed with cancer: A systematic review of implementation outcomes. *BMC Cancer*. 2021 May;21(643). doi.org/10.1186/s12885-021-08196-7

Supplementary Table 1: Search strategy

	Cancer	Exercise	Implementation outcomes	Evidence
Medline Title/Abstract Terms	cancer OR malignan* OR oncolog* OR neoplasm* OR tumor OR tumour OR carcinoma OR chemotherapy OR radiotherapy OR androgen deprivation OR mastectomy OR lumpectomy OR pneumonectomy OR lobectomy OR colectomy OR bowel resection OR prostatectomy OR laryngectomy OR esophagectomy OR gastrectomy	exercis* OR "weight lifting" OR sport* OR "strength training" OR "resistance training" OR aerobic OR walk* OR fitness OR "physical activit*"	(Acceptab* Or Satisf*) OR (Adopt* OR Uptake OR utili*OR implement* OR "intention to try" OR barrier* OR enable* OR facilitate*) OR (Appropriat* OR "perceived fit" OR relevan* OR compat* OR suitab* OR useful* OR practica*) OR (cost* OR economic* OR finance*) OR (Feasibil*OR Utili* OR Practica*) OR (Fidelity OR Integrity OR "delivered as intended" OR adhere* OR "quality of program delivery") OR (Penetrat* OR integrat* OR "spread" OR "service access") OR (Sustain* OR maintenance OR continu* OR durab* OR incorporate*OR integrat* OR institutionaliz* OR maintain* OR routin*OR institutionalis*)	Innovat* OR EBP OR evidence* OR empirical* OR evaluat*
Medline MeSH Terms	(MH "Neoplasms") OR (MH "Radiation Oncology") OR (MH "Medical Oncology")	(MH "Exercise Therapy") OR (MH "Exercise") OR (MH "Plyometric Exercise") OR (MH "Resistance Training") OR (MH "Physical Conditioning, Human") OR (MH "Muscle Stretching Exercises") OR (MH "Circuit-Based Exercise") OR (MH "Exercise Movement Techniques") OR (MH "Walking") OR (MH "Weight Lifting") OR (MH "Sports")	(MH "Patient Satisfaction") OR (MH "Intention") OR (MH "Costs and Cost Analysis") OR (MH "Cost-Benefit Analysis") OR (MH "Cost Savings") OR (MH "Cost of Illness") OR (MH "Quality Control") OR (MH "Delivery of health care") OR (MH "Comprehensive health care") OR ("MH "Quality of health care")	(MH "Evidence-Based Practice") OR (MH "Evidence-Based Medicine") OR (MH "diffusion of innovation") OR (MH "Program Evaluation")

Supplementary Table 2: Definitions of terms for study classification

Term	Definition	Categorisation in this paper
Pilot study	Pilot studies are a version of the main study that is run in miniature to test whether the components of the main study can work together. It is focused on ensuring that the processes of the main study (e.g., recruitment, randomisation, treatment, and follow-up assessments) all run smoothly [102].	**Excluded**
Efficacy study	Efficacy trials (explanatory trials) determine whether an intervention produces the expected result under ideal circumstances [103].	**Excluded**
Effectiveness	Determines the impact of an intervention with demonstrated efficacy when it is delivered under 'real-world' conditions [81].	**Effectiveness**
Implementation	The process of putting to use or integrating evidence-based interventions within a setting [81].	**Implementation**
Implementation research	The scientific study of the use of strategies to adopt and integrate evidence-based health interventions into clinical and community settings to improve individual outcomes and benefit population health [104].	**Implementation**

Supplementary Table 3: Quality assessment

Mixed methods

Author	Year	Are there clear research questions?	Do the collected data allow to address the research questions?	Is there an adequate rationale for using a mixed method design to address the research question?	Are the different components of the study effectively integrated to answer the research question?	Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?
Beidas	2014	Yes	Yes	Yes	Yes	Yes	Unclear	Yes
Dennett	2017	Yes	Yes	Yes	Unclear	Unclear	No	Yes

Cross-sectional

Author	Year	Were the criteria for inclusion in the sample clearly defined?	Were the study subjects and the setting described in detail?	Was the exposure measured in a valid and reliable way?	Were objective, standard criteria used for measurement of the condition?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the outcomes measured in a valid and reliable way?	Was appropriate statistical analysis used?
Bultijnck	2018	Unclear	Yes	Yes	Yes	Not applicable	Not applicable	Yes	Yes

Quasi-experimental

Author	Year	Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?	Were the participants included in any comparisons similar?	Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	Was there a control group?	Were there multiple measurements of the outcome both pre and post the intervention/exposure	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?	Were the outcomes of participants included in any comparisons measured in the same way?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?
Brown	2019	Yes	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes
Culos-Reed	2019	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear
Dolan	2018	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Haas	2012	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear
Kirkham	2018	Yes	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes
Kirkham	2019	Yes	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes
Leach	2015	Yes	Yes	Yes	No	Yes	Unclear	Yes	Yes	Unclear
Leach	2016	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Yes
MacKenzie	2013	Yes	Unclear	Yes	No	Yes	Unclear	Yes	Yes	Yes
Muraca	2011	Not applicable	Yes	Unclear	No	No	No	Not applicable	Unclear	Unclear
Rajotte	2012	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Santa Mina	2019	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Sherman	2010	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Unclear	Unclear
Speed-Andrews	2012	Yes	Yes	Yes	No	Unclear	Not applicable	Yes	Yes	No

Swenson	2014	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Unclear
VanGerpen	2013	Yes	Yes	Yes	No	Yes	No	Yes	No	Unclear

Text and opinion

Author	**Year**	**Is the source of the opinion clearly identified?**	**Does the source of opinion have standing in the field of expertise?**	**Are the interests of the relevant population the central focus of the opinion?**	**Is the stated position the result of an analytical process, and is there logic in the opinion expressed?**	**Is there reference to the extant literature?**	**Is any incongruence with the literature/sources logically defended?**
Dazell	2015	Yes	Yes	Yes	Yes	Yes	Not applicable
Haas	2011	Yes	Yes	Yes	Yes	Yes	Not applicable
Heston	2018	Yes	Yes	Yes	Yes	Yes	Not applicable
Kimmel	2014	Yes	Yes	Yes	Yes	Yes	Not applicable
Leach	2014	Yes	Yes	Yes	Yes	Yes	Not applicable
Rogers	2019	Yes	Yes	Yes	Yes	Yes	Not applicable
Santa Mina	2012	Yes	Yes	Yes	Yes	Yes	Not applicable
Wurz	2013	Yes	Yes	Yes	Yes	Yes	Not applicable

Case series

Author	**Year**	**Were there clear criteria for inclusion in the case series?**	**Was the condition measured in a standard, reliable way for all participants included in the case series?**	**Were valid methods used for identification of the condition for all participants included in the case series?**	**Did the case series have consecutive inclusion of participants?**	**Did the case series have complete inclusion of participants?**	**Was there clear reporting of the demographics of the participants in the study?**	**Was there clear reporting of clinical information of the participants?**	**Were the outcomes or follow up results of cases clearly reported?**	**Was there clear reporting of the presenting site(s)/clinic(s) demographic information?**	**Was statistical analysis appropriate?**
Kirkham	2016	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Marker	2018	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Noble	2012	Yes	Yes	Unclear	Yes	No	Yes	Yes	Yes	Yes	Unclear

Cohort

Author	**Year**	**Were the two groups similar and recruited from the same population?**	**Were the exposures measured similarly to assign people to both exposed and unexposed groups?**	**Was the exposure measured in a valid and reliable way?**	**Were confounding factors identified?**	**Were strategies to deal with confounding factors stated?**	**Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?**	**Were the outcomes measured in a valid and reliable way?**	**Was the follow up time reported and sufficient to be long enough for outcomes to occur?**	**Was follow up complete, and if not, were the reasons to loss to follow up described and explored?**	**Were strategies to address incomplete follow up utilized?**	**Was appropriate statistical analysis used?**
Cheifetz	2014	No	No	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Cheifetz	2015	No	No	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Santa Mina	2017	Not applicable	Yes	Unclear	Not applicable	Not applicable	Yes	Yes	Yes	Yes	Yes	Yes

Qualitative

Author	Year	Is there congruity between the stated philosophical perspective and the research methodology?	Is there congruity between the research methodology and the research question or objectives?	Is there congruity between the research methodology and the methods used to collect data?	Is there congruity between the research methodology and the representation and analysis of data?	Is there congruity between the research methodology and the interpretation of results?	Is there a statement locating the researcher culturally or theoretically?	Is the influence of the researcher on the research, and vice- versa, addressed?	Are participants, and their voices, adequately represented?	Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?
Culos-Reed	2019	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes

Randomised control trial

Author	Year	Was true randomization used for assignment of participants to treatment groups?	Was allocation to treatment groups concealed?	Were treatment groups similar at the baseline?	Were participants blind to treatment assignment?	Were those delivering treatment blind to treatment assignment?	Were outcomes assessors blind to treatment assignment?	Were treatment groups treated identically other than the intervention of interest?	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?	Were participants analysed in the groups to which they were randomized?	Were outcomes measured in the same way for treatment groups?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?
Irwin	2017	Yes	No	Yes	Unclear	No	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Bjerre	2018	Yes	Yes	Unclear	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bjerre	2019	Yes	Yes	Unclear	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Supplementary Table 4: Excluded studies

1 = no intervention (not an active intervention) 2 = study design excluded (efficacy) 3 = wrong outcomes excluded (i.e., clinical outcomes) 4 = patient population excluded (include palliative or under 18 years) 5 = unable to source

Author	**Year**	**Title**	**Reason for exclusion**
Abbott, Linda; Hooke, Mary Catherine	2017	Energy through Motion: An activity intervention for cancer-related fatigue in an ambulatory infusion center	1
Adams, B. E.; Yochem, A.; Minick, K.; Brennan, G. P.	2018	A comparison of outcomes for a standardized versus nonstandardized physical therapy protocol in an acute care bone marrow transplant unit	1
Adamsen, Lis; Midtgaard, Julie; Rorth, Mikael; Borregaard, Niels; Andersen, Christina; Quist, Morten; Møller, Tom; Zacho, Morten; Madsen, Jan K.; Knutsen, Lasse	2003	Feasibility, physical capacity, and health benefits of a multidimensional exercise program for cancer patients undergoing chemotherapy	2
Adamsen, Lis; Quist, Morten; Midtgaard, Julie; Andersen, Christina; Møller, Tom; Knutsen, Lasse; Tveterås, Anders; Rorth, Mikael	2006	The effect of a multidimensional exercise intervention on physical capacity, well-being and quality of life in cancer patients undergoing chemotherapy	2
Alibhai, Shabbir Mh; Santa Mina, Daniel; Ritvo, Paul; Sabiston, Catherine; Krahn, Murray; Tomlinson, George; Matthew, Andrew; Segal, Roanne; Warde, Padraig; Durbano, Sara; O'Neill, Meagan; Culos-Reed, Nicole; Alibhai, Shabbir M. H.	2015	A phase II RCT and economic analysis of three exercise delivery methods in men with prostate cancer on androgen deprivation therapy	2
Alibhai, Shabbir M. H.; Santa Mina, Daniel; Ritvo, Paul; Tomlinson, George; Sabiston, Catherine; Krahn, Murray; Durbano, Sara; Matthew, Andrew; Warde, Padraig; O'Neill, Meagan; Timilshina, Narhari; Segal, Roanne; Culos-Reed, Nicole	2019	A phase II randomized controlled trial of three exercise delivery methods in men with prostate cancer on androgen deprivation therapy	2
Amritanshu, Ram R.; Rao, Raghavendra Mohan; Nagaratna, Raghuram; Veldore, Vidya Harini; Rani, Usha; Gopinath, Kodaganur S.; Ajaikumar, B. S.	2017	Effect of long-term yoga practice on psychological outcomes in Breast Cancer Survivors	2
Ammitzbøll, Gunn; Lanng, Charlotte; Kroman, Niels; Zerahn, Bo; Hyldegaard, Ole; Kaae Andersen, Klaus; Johansen, Christoffer; Dalton, Susanne Oksbjerg	2017	Progressive strength training to prevent LYmphoedema in the first year after breast CAncer – the LYCA feasibility study	2
Andersen, C.; Adamsen, L.; Moeller, T.; Midtgaard, J.; Quist, M.; Tveteraas, A.; Rorth, M.	2006	The effect of a multidimensional exercise programme on symptoms and side-effects in cancer patients undergoing chemotherapy-the use of semi-structured diaries	2
Arem, Hannah; Sorkin, Mia; Cartmel, Brenda; Fiellin, Martha; Capozza, Scott; Harrigan, Maura; Ercolano, Elizabeth; Zhou, Yang; Sanft, Tara; Gross, Cary; Schmitz, Kathryn; Neogi, Tuhina; Hershman, Dawn; Ligibel, Jennifer; Irwin, Melinda L.	2016	Exercise adherence in a randomized trial of exercise on aromatase inhibitor arthralgias in breast cancer survivors: The Hormones and Physical Exercise (HOPE) Study	2
Armbruster, Shannon D.; Song, Jaejoon; Gatus, Leticia; Lu, Karen H.; Basen-Engquist, Karen M.	2018	Endometrial cancer survivors' sleep patterns before and after a physical activity intervention: A retrospective cohort analysis	2

Bade, Brett C.; Hyer, J. Madison; Bevill, Benjamin T.; Pastis, Alex; Rojewski, Alana M.; Toll, Benjamin A.; Silvestri, Gerard A	2018	A patient-centered activity regimen improves participation in physical activity interventions in advanced-stage lung cancer	1
Blackburn, Roxann; Presson, Kimberly; Laufman, Robin; Tomczak, Nancy; Brassil, Kelly J.	2016	Establishing an inpatient gym for recipients of stem cell transplantation: A multidisciplinary collaborative	4
Blaney, Janine; Lowe-Strong, Andrea; Rankin, Jane; Campbell, Anna; Allen, James; Gracey, Jackie	2010	The cancer rehabilitation journey: Barriers to and facilitators of exercise among patients with cancer-related fatigue	4
Bolam K, Mijwel S, Rundqvist H, Wengstrom Y	2019	Two-year follow-up of the Opti-Train randomised controlled exercise trial	2
Bourke, Liam; Doll, Helen; Crank, Helen; Daley, Amanda; Rosario, Derek; Saxton, John M.	2011	Lifestyle intervention in men with advanced prostate cancer receiving androgen suppression therapy: A feasibility study	2
Bositis, A.; Scanlon, T. S.; Hall, P. S.; Mock, V.	2004	Increasing exercise adherence in a clinical trial evaluating the effectiveness of exercise on cancer treatment-related fatigue	3
Broderick, J. M.; Guinan, E.; Kennedy, M. J.; Hollywood, D.; Courneya, K. S.; Culos-Reed, S. N.; Bennett, K.; O' Donnell, D. M.; Hussey, J.	2013	Feasibility and efficacy of a supervised exercise intervention in de-conditioned cancer survivors during the early survivorship phase: The PEACH trial	2
Broderick, J. M.; Guinan, E.; O' Donnell, D. M.; Hussey, J.; Tyrrell, E.; Normand, C.	2014	Calculating the costs of an 8-week, physiotherapy-led exercise intervention in deconditioned cancer survivors in the early survivorship period (the PEACH trial)	2
Carmack Taylor, Cindy L.; Demoor, Carl; Smith, Murray A.; Dunn, Andrea L.; Basen-Engquist, Karen; Nielsen, Ingrid; Pettaway, Curtis; Sellin, Rena; Massey, Pamela; Gritz, Ellen R.	2006	Active for Life After Cancer: A randomized trial examining a lifestyle physical activity program for prostate cancer patients	1
Capozzi, Lauren C.; Boldt, Kevin R.; Lau, Harold; Shirt, Lisa; Bultz, Barry; Culos-Reed, S. Nicole	2015	A clinic-supported group exercise program for head and neck cancer survivors: Managing cancer and treatment side effects to improve quality of life	2
Christensen, Jesper Frank; Simonsen, Casper; Hojman, Pernille	2018	Exercise training in cancer control and treatment	2
Colombo, Reyna; Doherty, Deborah; Seidell, Janet Wiechec; Linn, Stacy; Drouin, Jacqueline S	2015	Design, implementation, and sustainability of physical therapy in a comprehensive oncology survivorship program - A case report	1
Cormie, Prue; Turner, Brooke; Kaczmarek, Elizabeth; Drake, Deirdre; Chambers, Suzanne K	2015	A qualitative exploration of the experience of men with prostate cancer involved in supervised exercise programs	3
Courneya, Kerry S.; Segal, Roanne J.; Mackey, John R.; Gelmon, Karen; Reid, Robert D.; Friedenreich, Christine M.; Ladha, Aliya B.; Proulx, Caroline; Vallance, Jeffrey K. H.; Lane, Kirstin; Yasui, Yutaka; McKenzie, Donald C.	2007	Effects of aerobic and resistance exercise in breast cancer patients receiving adjuvant chemotherapy: A multicenter randomized controlled trial	3
Courneya, Kerry S.; Segal, Roanne J.; Gelmon, Karen; Reid, Robert D.; Mackey, John R.; Friedenreich, Christine M.; Proulx, Caroline; Lane, Kirstin; Ladha, Aliya B.; Vallance, Jeffrey K.; McKenzie, Donald C.	2008	Predictors of supervised exercise adherence during breast cancer chemotherapy	2
Demark-Wahnefried, Wendy; Rogers, Laura Q.; Alfano, Catherine M.; Thomson, Cynthia A.; Courneya, Kerry S.; Meyerhardt, Jeffrey A.; Stout, Nicole L.; Kvale, Elizabeth; Ganzer, Heidi; Ligibel, Jennifer A.	2015	Practical clinical interventions for diet, physical activity, and weight control in cancer survivors	3
Demark-Wahnefried, Wendy; Schmitz, Kathryn H.; Alfano, Catherine M.; Bail, Jennifer R.; Goodwin, Pamela J.;	2018	Weight management and physical activity throughout the cancer care continuum	3

Thomson, Cynthia A.; Bradley, Don W.; Courneya, Kerry S.; Befort, Christie A.; Denlinger, Crystal S.; Ligibel, Jennifer A.; Dietz, William H.; Stolley, Melinda R.; Irwin, Melinda L.; Bamman, Marcas M.; Apovian, Caroline M.; Pinto, Bernardine M.; Wolin, Kathleen Y.; Ballard, Rachel M.; Dannenberg, Andrew J.; Eakin, Elizabeth G.; Longjohn, Matt M.; Raffa, Susan D.; Adams-Campbell, Lucile L.; Buzaglo, Joanne S.; Nass, Sharyl J.; Massetti, Greta M.; Balogh, Erin P.; Kraft, Elizabeth S.; Parekh, Anand K.; Sanghavi, Darshak M.; Morris, G. Stephen; Basen-Engquist, Karen			
Donnelly, C. M.; Blaney, J. M.; Lowe-Strong, A.; Rankin, J. P.; Campbell, A.; McCrum-Gardner, E.; Gracey, J. H	2011	A randomised controlled trial testing the feasibility and efficacy of a physical activity behavioural change intervention in managing fatigue with gynaecological cancer survivors	2
Eakin, Elizabeth G.; Hayes, Sandra C.; Haas, Marion R.; Reeves, Marina M.; Vardy, Janette L.; Boyle, Frances; Hiller, Janet E.; Mishra, Gita D.; Goode, Ana D.; Jefford, Michael; Koczwara, Bogda; Saunders, Christobel M.; Demark-Wahnefried, Wendy; Courneya, Kerry S.; Schmitz, Kathryn H.; Girgis, Afaf; White, Kate; Chapman, Kathy; Boltong, Anna G.; Lane, Katherine; McKiernan, Sandy; Millar, Lesley; O'Brien, Lorna; Sharplin, Greg; Baldwin, Polly; Robson, Erin L.	2015	Healthy Living after Cancer: A dissemination and implementation study evaluating a telephone-delivered healthy lifestyle program for cancer survivors	2
Eckert, Katharina; Lange, Martin; Huber, Gerhard	2012	Effects of supplemental behavior-oriented exercise intervention in a disease management program for breast cancer	3
Fong, A. J.; Jones, J. M.; Faulkner, G.; Sabiston, C. M	2018	Exploring cancer centres for physical activity and sedentary behaviour support for breast cancer survivors	1
Fong, Angela J.; Faulkner, Guy; Jones, Jennifer M.; Sabiston, Catherine M.	2018	A qualitative analysis of oncology clinicians' perceptions and barriers for physical activity counselling in breast cancer survivors	1
Foucaut, Aude-Marie; Morelle, Magali; Kempf-Lépine, Anne-Sophie; Baudinet, Cédric; Meyrand, Renaud; Guillemaut, Séverine; Metzger, Séverine; Bourne-Branchu, Valérie; Grinand, Elodie; Chabaud, Sylvie; Pérol, David; Carretier, Julien; Berthouze, Sophie E.; Reynes, Eric; Perrier, Lionel; Rebattu, Paul; Heudel, Pierre-Etienne; Bachelot, Thomas; Bachmann, Patrick; Fervers, Béatrice; Trédan, Olivier; Touillaud, Marina	2019	Feasibility of an exercise and nutritional intervention for weight management during adjuvant treatment for localized breast cancer: The PASAPAS randomized controlled trial	2
Fox, L.; Cahill, F.; Burgess, C.; Peat, N.; Rudman, S.; Kinsella, J.; Cahill, D.; George, G.; Santaolalla, A.; Van Hemelrijck, M.	2017	Real world evidence: A quantitative and qualitative glance at participant feedback from a free-response survey investigating experiences of a structured exercise intervention for men with prostate cancer	3
Freitag, Nils; Weber, Pia Deborah; Sanders, Tanja Christiane; Schulz, Holger; Bloch, Wilhelm; Schumann, Moritz	2018	High-intensity interval training and hyperoxia during chemotherapy: A case report about the feasibility, safety and physical functioning in a colorectal cancer patient -	2
Galvão, Daniel A.; Newton, Robert U.; Girgis, Afaf; Lepore, Stephen J.; Stiller, Anna; Mihalopoulos, Cathrine; Gardiner, Robert A.; Taaffe, Dennis R.; Occhipinti, Stefano; Chambers, Suzanne K.	2018	Randomized controlled trial of a peer led multimodal intervention for men with prostate cancer to increase exercise participation	1

Gell, Nancy M.; Grover, Kristin W.; Humble, Morgan; Sexton, Michelle; Dittus, Kim	2017	Efficacy, feasibility, and acceptability of a novel technology-based intervention to support physical activity in cancer survivors	2
Grabenbauer, Alexander; Grabenbauer, Andrea J.; Lengenfelder, Rosa; Grabenbauer, Gerhard G.; Distel, Luitpold V.	2016	Feasibility of a 12-month-exercise intervention during and after radiation and chemotherapy in cancer patients: impact on quality of life, peak oxygen consumption, and body composition	2
Granger, Catherine L.; Denehy, Linda; Remedios, Louisa; Retica, Sarah; Phongpagdi, Pimsiri; Hart, Nicholas; Parry, Selina M.	2016	Barriers to translation of physical activity into the lung cancer model of care. A qualitative study of clinicians' perspectives	1
Granger, Catherine L.; Parry, Selina M.; Denehy, Linda; Remedios, Louisa	2018	Evidence, education and multi-disciplinary integration are needed to embed exercise into lung cancer clinical care: A qualitative study involving physiotherapists	1
Greterman, Sarah Jane	2018	Changes in physical activity and quality of life of cancer survivors participating in a group exercise program	2
Groeneveldt, Lara; Mein, Gill; Garrod, Rachel; Jewell, Andrew P.; Van Someren, Ken; Stephens, Richard; D'Sa, Shirley P.; Yong, Kwee L	2013	A mixed exercise training programme is feasible and safe and may improve quality of life and muscle strength in multiple myeloma survivors	2
Haines, T. P.; Sinnamon, P.; Wetzig, N. G.; Lehman, M.; Walpole, E.; Pratt, T.; Smith, A.	2010	Multimodal exercise improves quality of life of women being treated for breast cancer, but at what cost? Randomized trial with economic evaluation	2
Haussmann, Alexander; Gabrian, Martina; Ungar, Nadine; Jooß, Stefan; Wiskemann, Joachim; Sieverding, Monika; Steindorf, Karen	2018	What hinders healthcare professionals in promoting physical activity towards cancer patients? The influencing role of healthcare professionals' concerns, perceived patient characteristics and perceived structural factors	1
Hayes, Sandra C.; Johansson, Karin; Alfano, Catherine M.; Schmitz, Kathryn	2011	Exercise for breast cancer survivors: Bridging the gap between evidence and practice	2
Hayes, Sandra; Rye, Sheree; Battistutta, Diana; Yates, Patsy; Pyke, Chris; Bashford, John; Eakin, Elizabeth	2011	Design and implementation of the Exercise for Health trial - A pragmatic exercise intervention for women with breast cancer	3
Hayes, Sandra C.; Rye, Sheree; Disipio, Tracey; Yates, Patsy; Bashford, John; Pyke, Chris; Saunders, Christobel; Battistutta, Diana; Eakin, Elizabeth	2013	Exercise for health: A randomized, controlled trial evaluating the impact of a pragmatic, translational exercise intervention on the quality of life, function and treatment-related side effects following breast cancer	2
Hoffman, Amy J.; Brintnall, Ruth Ann; Brown, Jean K.; von Eye, Alexander; Jones, Lee W.; Alderink, Gordon; Ritz-Holland, Debbie; Enter, Mark; Patzelt, Lawrence H.; VanOtteren, Glenn M.	2013	Too sick not to exercise	2
Hoffman, Amy J.; Brintnall, Ruth Ann	2017	A home-based exercise intervention for non-small cell lung cancer patients post-thoracotomy	1
Huether, Katie; Abbott, Linda; Cullen, Laura; Cullen, Liz; Gaarde, Ami	2016	Energy Through Motion©: An evidence-based exercise program to reduce cancer-related fatigue and improve quality of life	1
Hubbard, Gill; Campbell, Anna; Fisher, Abi; Harvie, Michelle; Maltinsky, Wendy; Mullen, Russell; Banks, Elspeth; Gracey, Jackie; Gorely, Trish; Munro, Julie; Ozakinci, Gozde	2018	Physical activity referral to cardiac rehabilitation, leisure centre or telephone-delivered consultations in post-surgical people with breast cancer: A mixed methods process evaluation	4
Hubbard, Gill; Adams, Richard; Campbell, Anna; Kidd, Lisa; Leslie, Stephen J.; Munro, Julie; Watson, Angus	2016	Is referral of postsurgical colorectal cancer survivors to cardiac rehabilitation feasible and acceptable? A pragmatic pilot randomised controlled trial with embedded qualitative study	2
Irwin - British Journal of Sports Medicine	2009	Physical activity interventions for cancer survivors	1
Jahn, Patrick; Lakowa, Nicole; Landenberger, Margarete; Vordermark, Dirk; Stoll, Oliver	2012	InterACTIV: An exploratory study of the use of a game console to promote physical activation of hospitalized adult patients with cancer	2

Johansson, Karin; Hayes, Sandi; Speck, Rebecca M.; Schmitz, Kathryn H.	2013	Water-based exercise for patients with chronic arm lymphedema: A randomized controlled pilot trial	3
James-Martin, G.; Koczwara, B.; Smith, E. L.; Miller, M. D.	2014	Information needs of cancer patients and survivors regarding diet, exercise and weight management: A qualitative study	1
Kampshoff, C, van Dongen J, va Mechelen W, Schep G, Vreugdenhil A, Twisk J, Bosman J, Brug J, Chinapaw M, Buffart L.	2018	Long-term effectiveness and cost-effectiveness of high versus low-to-moderate intensity resistance and endurance exercise interventions among cancer survivors	2
Kristiansen, Maria; Adamsen, Lis; Piil, Karin; Halvorsen, Ida; Nyholm, Nanna; Hendriksen, Carsten	2017	A three-year national follow-up study on the development of community-level cancer rehabilitation in Denmark	1
Knobf, M. Tish; Thompson, A. Siobhan; Fennie, Kristopher; Erdos, Diane	2014	The effect of a community-based exercise intervention on symptoms and quality of life	2
Kim, Soo Hyun; Shin, Mi Soon; Lee, Han Sul; Lee, Eun Sook; Ro, Jung Sil; Kang, Han Sung; Kim, Seok Won; Lee, Won Hee; Kim, Hee Soon; Kim, Chun Ja; Kim, Joohyung; Yun, Young Ho	2011	Randomized pilot test of a simultaneous stage-matched exercise and diet intervention for breast cancer survivors	2
Kim, Sue; Ko, Yun Hee; Song, Yoonkyung; Kang, Min Jae; Lee, Hyojin; Kim, Sung Hae; Jeon, Justin Y.; Cho, Young Up; Yi, Gihong; Han, Jeehee	2019	Development of an exercise adherence program for breast cancer survivors with cancer-related fatigue-an intervention mapping approach	3
Kwiatkowski, Fabrice; Mouret-Reynier, Marie-Ange; Duclos, Martine; Bridon, François; Hanh, Thierry; Van Praagh-Doreau, Isabelle; Travade, Armelle; Vasson, Marie-Paule; Jouvency, Sylvie; Roques, Christian; Bignon, Yves-Jean	2017	Long-term improvement of breast cancer survivors' quality of life by a 2-week group physical and educational intervention: 5-year update of the 'PACThe' trial	1
Kuehr, L. E. A.; Wiskemann, Joachim; Abel, Ulrich; Ulrich, Cornelia M.; Hummler, Simone; Thomas, Michael	2014	Exercise in patients with non-small cell lung cancer	2
Ligibel, Jennifer A.; Jones, Lee W.; Brewster, Abenaa M.; Clinton, Steven K.; Korde, Larissa A.; Oeffinger, Kevin C.; Bender, Catherine M.; Tan, Winston; Merrill, Janette K.; Katta, Sweatha Alfano; Catherine M.	2019	Oncologists' attitudes and practice of addressing diet, physical activity, and weight management with patients with cancer: Findings of an ASCO survey of the oncology workforce	1
Loh, Kah Poh; Kleckner, Ian R.; Lin, Po-Ju; Mohile, Supriya G.; Canin, Beverly E.; Flannery, Marie A.; Fung, Chunkit; Dunne, Richard F.; Bautista, Javier; Culakova, Eva; Kleckner, Amber S.; Peppone, Luke J.; Janelsins, Michelle; McHugh, Colin; Conlin, Alison; Cho, Jonathan K.; Kasbari, Sameer; Esparaz, Benjamin T.; Kuebler, J. Philip; Mustian, Karen M.	2019	Effects of a home-based exercise program on anxiety and mood disturbances in older adults with cancer receiving chemotherapy	2
Lee, Morgan S.; Small, Brent J.; Jacobsen, Paul B.	2017	Rethinking barriers: A novel conceptualization of exercise barriers in cancer survivors	1
Macleod, Maureen; Steele, Robert J. C.; O'Carroll, Ronan E.; Wells, Mary; Campbell, Anna; Sugden, Jacqui A.; Rodger, Jackie; Stead, Martine; McKell, Jennifer; Anderson, Annie S.	2018	Feasibility study to assess the delivery of a lifestyle intervention (TreatWELL) for patients with colorectal cancer undergoing potentially curative treatment	2
Marthick, Michael; Grant, Suzanne J.; Lacey, Judith	2019	Establishing an integrative oncology service in the Australian healthcare setting-the Chris O'Brien Lifehouse Hospital experience	1
McIntosh, Megan; Opozda, Melissa; Galvão, Daniel A.; Chambers, Suzanne K.; Short, Camille E.	2019	Identifying the exercise-based support needs and exercise programme preferences among men with	3

		prostate cancer during active surveillance: A qualitative study	
Matthews, Charles E.; Wilcox, Sara; Hanby, Cara L.; Der Ananian, Cheryl; Heiney, Sue P.; Gebretsadik, Tebeb; Shintani, Ayumi	2007	Evaluation of a 12-week home-based walking intervention for breast cancer survivors	2
Maxwell-Smith, Chloe; Zeps, Nik; Hagger, Martin S.; Platell, Cameron; Hardcastle, Sarah J.	2017	Barriers to physical activity participation in colorectal cancer survivors at high risk of cardiovascular disease	3
Mayer, Deborah K.; Landucci, Gina; Awoyinka, Lola; Atwood, Amy K.; Carmack, Cindy L.; Demark-Wahnefried, Wendy; McTavish, Fiona; Gustafson, David H.	2018	SurvivorCHESS to increase physical activity in colon cancer survivors: Can we get them moving?	1
Mewes, Janne C.; Steuten, Lotte M. G.; Ijsbrandy, Charlotte; Ijzerman, Maarten J.; van Harten, Wim H.	2017	Value of implementation of strategies to increase the adherence of health professionals and cancer survivors to guideline-based physical exercise	4
Midtgaard, J.; Røssell, K.; Christensen, J. F.; Uth, J.; Adamsen, L.; Rørth, M.; Midtgaard, Julie; Røssell, Kasper; Christensen, Jesper Frank; Uth, Jacob; Adamsen, Lis; Rørth, Mikael	2012	Demonstration and manifestation of self-determination and illness resistance--a qualitative study of long-term maintenance of physical activity in posttreatment cancer survivors	3
Mehnert, Anja; Veers, Silke; Howaldt, Dirk; Braumann, Klaus-Michael; Koch, Uwe; Schulz, Karl-Heinz	2011	Effects of a physical exercise rehabilitation group program on anxiety, depression, body image, and health-related quality of life among breast cancer patients	2
Musanti, Rita; Ying-Yu, Chao; Collins, Katelyn	2019	Fitness and quality of life outcomes of cancer survivor participants in a community exercise program	3
Nadler, Michelle B.; Bainbridge, Daryl; Fong, Angela J.; Sussman, Jonathan; Tomasone, Jennifer R.; Neil-Sztramko, Sarah E.	2019	Moving Cancer Care Ontario's Exercise for People with Cancer guidelines into oncology practice: Using the Theoretical Domains Framework to validate a questionnaire	3
Nock, Nora L.; Owusu, Cynthia; Kullman, Emily L.; Austin, Kris; Roth, Beth; Cerne, Stephen; Harmon, Carl; Moore, Halle; Vargo, Mary; Hergenroeder, Paul; Malone, Hermione; Rocco, Michael; Tracy, Russell; Lazarus, Hillard M.; Kirwan, John P.; Heyman, Ellen; Berger, Nathan A.	2013	A community-based exercise and support group program in African-American Breast Cancer Survivors (ABCs)	2
Olivier, Cecile; Grosbois, Jean-Marie; Cortot, Alexis B.; Peres, Sophie; Heron, Christophe; Delourme, Julie; Gierczynski, Marianne; Hoorelbeke, Anne; Scherpereel, Arnaud; Le Rouzic, Olivier	2018	Real-life feasibility of home-based pulmonary rehabilitation in chemotherapy-treated patients with thoracic cancers: A pilot study	2
Oertle, Staci; Burrell, Sherry; Pirollo, Melanie	2016	Evaluating the effects of a physician-referred exercise program on cancer-related fatigue and quality of life among early cancer survivors	2
Ottenbacher, A. J.; Day, R. S.; Taylor, W. C.; Sharma, S. V.; Sloane, R.; Snyder, D. C.; Lipkus, I. M.; Jones, L. W.; Demark-Wahnefried, W.; Ottenbacher, Allison J.; Day, R. Sue; Taylor, Wendell C.; Sharma, Shreela V.; Sloane, Richard; Snyder, Denise C.; Lipkus, Isaac M.; Jones, Lee W.; Demark-Wahnefried, Wendy	2012	Long-term physical activity outcomes of home-based lifestyle interventions among breast and prostate cancer survivors	1
Pullen, Tanya; Sharp, Paul; Bottorff, Joan L.; Sabiston, Catherine M.; Campbell, Kristin L.; Ellard, Susan L.; Gotay, Carolyn; Fitzpatrick, Kayla; Caperchione, Cristina M.	2018	Acceptability and satisfaction of project MOVE: A pragmatic feasibility trial aimed at increasing physical activity in female breast cancer survivors	4
Pablo, Susana; Arietaleanizbeaskoa, Maria Soledad; Mendizabal, Nere; Luis, Raquel;	2019	Linkages between health and community organizations for increasing longterm adherence to	2

Gil, Erreka; de la Fuente, Ibon; Rogers, Heather; Grandes, Gonzalo		physical exercise: Experiences of patients involved in the EfiKroniK Program	
Parker, Nathan H.; Lee, Rebecca E.; O'Connor, Daniel P.; An, Ngo-Huang; Petzel, Maria Q. B.; Schadler, Keri; Xuemei, Wang; Lianchun, Xiao; Fogelman, David; Simpson, Richard; Fleming, Jason B.; Lee, Jeffrey E.; Ching-Wei, D. Tzeng; Sahai, Sunil K.; Basen-Engquist, Karen; Katz, Matthew H. G.	2019	Supports and barriers to home-based physical activity during preoperative treatment of pancreatic cancer: A mixed-methods study	3
Peddle-McIntyre, C. J.; Baker, M. K.; Lee, Y. C. G.; Galvão, D. A.; Cormie, P.; Graham, V.; Newton, R. U.	2018	The feasibility of a pragmatic distance-based intervention to increase physical activity in lung cancer survivors	2
Peeters, C.; Stewart, A.; Segal, R.; Wouterloot, E.; Scott, C. G.; Aubry, T.	2009	Evaluation of a cancer exercise program: Patient and physician beliefs	1
Perrier, Lionel; Foucaut, Aude-Marie; Morelle, Magali; Touillaud, Marina; Kempf-Lépine, Anne-Sophie; Heinz, Dominik; Gomez, Frédéric; Meyrand, Renaud; Baudinet, Cédric; Berthouze, Sophie; Reynes, Eric; Carretier, Julien; Guillemaut, Séverine; Pérol, David; Trédan, Olivier; Philip, Thierry; Bachmann, Patrick; Fervers, Béatrice	2019	Cost-effectiveness of an exercise and nutritional intervention versus usual nutritional care during adjuvant treatment for localized breast cancer: The PASAPAS randomized controlled trial	3
Persoon, S.; Chinapaw, M. J. M.; Buffart, L. M.; Brug, J.; Kersten, M. J.; Nollet, F.	2018	Lessons learnt from a process evaluation of an exercise intervention in patients treated with autologous stem cell transplantation	4
Petersson, Lena-Marie; Berglund, Gunilla; Brodin, Ola; Glimelius, Bengt; Sjödén, Per-Olow	2000	Group rehabilitation for cancer patients: Satisfaction and perceived benefits	1
Phillips, Siobhan M.; Courneya, Kerry S.; Welch, Whitney A.; Gavin, Kara L.; Cottrell, Alison; Nielsen, Anne; Solk, Payton; Blanch-Hartigan, Danielle; Cella, David; Ackermann, Ronald T.; Spring, Bonnie; Penedo, Frank	2019	Breast cancer survivors' preferences for mHealth physical activity interventions: Findings from a mixed methods study	1
Pinto, B. M.; Rabin, C.; Dunsiger, S.; Pinto, Bernardine M.; Rabin, Carolyn; Dunsiger, Shira	2009	Home-based exercise among cancer survivors: Adherence and its predictors	2
Pinto, Bernardine; Waldemore, Marissa; Rosen, Rochelle	2015	A community-based partnership to promote exercise among cancer survivors: Lessons learned	1
Plumeau, K.; Marcyan, R. A.; Heubeck, A.; Thomas, Z.; Fitzsimons, J.; Mayer, J. E.	2019	Home exercise programs for cancer survivors: Can a weekly phone call impact compliance, function or quality of life?	2
Predeger, Elizabeth J.; O'Malley, Maureen; Hendrix, Thomas; Parker, Nadine M.	2014	Oncology rehabilitation outcomes over time: A mixed-methods approach	3
Pullen, Tanya; Bottorff, Joan L.; Sabiston, Catherine M.; Campbell, Kristin L.; Eves, Neil D.; Ellard, Susan L.; Gotay, Carolyn; Fitzpatrick, Kayla; Sharp, Paul; Caperchione, Cristina M.	2018	Utilizing RE-AIM to examine the translational potential of Project MOVE, a novel intervention for increasing physical activity levels in breast cancer survivors	4
Rabin, Carolyn; Pinto, Bernardine; Fava, Joseph	2016	Randomized trial of a physical activity and meditation intervention for young adult cancer survivors	2
Retèl, Valesca P.; van der Molen, Lisette; Hilgers, Frans J. M.; Rasch, Coen R. N.; L'Ortye, Annemiek A. A. M. H. J.; Steuten, Lotte M. G.; van Harten, Wim H.	2011	A cost-effectiveness analysis of a preventive exercise program for patients with advanced head and neck cancer treated with concomitant chemo-radiotherapy	3
Robertson, Lindsay; Richards, Rosalina; Egan, Richard; Szymlek-Gay, Ewa A.	2013	Promotion and support of physical activity among cancer survivors: A service provider perspective	1

Rogers, Laura Q.; Vicari, Sandy; Courneya, Kerry S.	2010	Lessons learned in the trenches: facilitating exercise adherence among breast cancer survivors in a group setting	3
Reynolds, Jana; Thibodeaux, Lorie; Jiang, Luohua; Francis, Kevin; Hochhalter, Angie	2015	Fit & strong! Promotes physical activity and well-being in older cancer survivors	2
Roagenhofer, S.; Wortz, I.; Widmann, T.	2015	Interim analysis of the SENSe-study structured evaluation of sustainability of sports after cancer	5
Roggenhofer, S.; Widmann, T.	2016	SENSe-Study interim analysis structured evaluation of sustainability of sports after cancer	5
Sabiston, Catherine M.; Fong, Angela J.; O'Loughlin, Erin K.; Meterissian, Sarkis	2019	A mixed-methods evaluation of a community physical activity program for breast cancer survivors	2
Santa Mina D, Sabiston C, Au D, Fong A, Capozzi L, Langelier D, Chasen M, Chiarotto J, Tomasone J, Jones J, Chang E, Culos-Reed S.	2018	Connecting people with cancer to physical activity and exercise programs: A pathway to create accessibility and engagement	1
Scaramuzzo, Leah A.; Gordils-Perez, Janet; Cullen, Patsy McGuire	2014	Getting patients active: using national data to drive practice	1
Schmidt, Thorsten; Schwarz, Madalena; Van Mackelenbergh, Marion; Jonat, Walter; Weisser, Burkhard; Röcken, Christoph; Mundhenke, Christoph	2017	Feasibility study to evaluate compliance of physical activity over a long time period and its influence on the total activity score, glucose metabolism and physical and psychological parameters following breast cancer	2
Schmitz, Kathryn H.	2017	Incorporating strength training into cancer care: Translating PAL into the strength after breast cancer program	1
Schmitz, Kathryn H.	2011	Exercise for secondary prevention of breast cancer: moving from evidence to changing clinical practice	1
Schmitz, Kathryn H.; Troxel, Andrea B.; Dean, Lorraine T.; DeMichele, Angela; Brown, Justin C.; Sturgeon, Kathleen; Zhang, Zi; Evangelisti, Margaret; Spinelli, Bryan; Kallan, Michael J.; Denlinger, Crystal; Cheville, Andrea; Winkels, Renate M.; Chodosh, Lewis; Sarwer, David B.	2019	Effect of home-based exercise and weight loss programs on breast cancer–related lymphedema outcomes among overweight breast cancer survivors: The WISER survivor randomized clinical trial	2
Schmitz, Kathryn H.; Campbell, Anna M.; Stuiver, Martijn M.; Pinto, Bernardine M.; Schwartz, Anna L.; Morris, G. Stephen; Ligibel, Jennifer A.; Cheville, Andrea; Galvão, Daniel A.; Alfano, Catherine M.; Patel, Alpa V.; Hue, Trisha; Gerber, Lynn H.; Sallis, Robert; Gusani, Niraj J.; Stout, Nicole L.; Chan, Leighton; Flowers, Fiona; Doyle, Colleen; Helmrich, Susan; Bain, William; Sokolof, Jonas; Winters-Stone, Kerri M.; Campbell, Kristin L.; Matthews, Charles E.	2019	Exercise is medicine in oncology: Engaging clinicians to help patients move through cancer	1
Schneider, C. M.; Dennehy, C. A.; Roozeboom, M.; Carter, S. D.	2002	A model program: Exercise intervention for cancer rehabilitation	3
Schumacher, Molly M.; McNiel, Paula	2018	The impact of Livestrong® at the YMCA for cancer survivors	3
Scott, Jessica M.; Iyengar, Neil M.; Nilsen, Tormod S.; Michalski, Meghan; Thomas, Samantha M.; Herndon, James, 2nd; Sasso, John; Yu, Anthony; Chandarlapaty, Sarat; Dang, Chau T.; Comen, Elizabeth A.; Dickler, Maura N.; Peppercorn, Jeffrey M.; Jones, Lee W.	2018	Feasibility, safety, and efficacy of aerobic training in pretreated patients with metastatic breast cancer: A randomized controlled trial	2
Sheehan, P.; Denieffe, S.; Harrison, M.	2016	Evaluation of a Sustainable Intervention using Exercise - for Cancer Fatigue (ESIE-CF Trial)	2

Sheill, G.; Guinan, E.; Neill, L. O.; Hevey, D.; Hussey, J.	2018	Physical activity and advanced cancer: The views of oncology and palliative care physicians in Ireland	1
Sheppard, Vanessa B.; Hicks, Jennifer; Makambi, Kepher; Hurtado-de-Mendoza, Alejandra; Demark-Wahnefried, Wendy; Adams-Campbell, Lucile	2016	The feasibility and acceptability of a diet and exercise trial in overweight and obese black breast cancer survivors: The Stepping STONE study	2
Short, Camille E.; James, Erica L.; Girgis, Afaf; D'Souza, Mario I.; Plotnikoff, Ronald C.	2015	Main outcomes of the Move More for Life Trial: A randomised controlled trial examining the effects of tailored-print and targeted-print materials for promoting physical activity among post-treatment breast cancer survivors	1
Short, Camille E.; James, Erica L.; Plotnikoff, Ronald C.	2013	Theory-and evidence-based development and process evaluation of the Move More for Life program: A tailored-print intervention designed to promote physical activity among post-treatment breast cancer survivors	3
Siedentopf, F.; Utz-Billing, I.; Gairing, S.; Schoenegg, W.; Kentenich, H.; Kollak, I.	2013	Yoga for patients with early breast cancer and its impact on quality of life - a randomized controlled trial	3
Smith-Turchyn, Jenna; Richardson, Julie; Tozer, Richard; McNeely, Margaret; Thabane, Lehana	2019	Bridging the gap: incorporating exercise evidence into clinical practice in breast cancer care	2
Spahn, Günther; Choi, Kyung-Eun; Ke	2013	Can a multimodal mind-body program enhance the treatment effects of physical activity in breast cancer survivors with chronic tumor-associated fatigue? A randomized controlled trial	2
Sprod, Lisa K.; Hsieh, City C.; Hayward, Reid; Schneider, Carole M.	2010	Three versus six months of exercise training in breast cancer survivors	2
Sremanakova, J.; Jones, D.; Cooke, R.; Burden, S.	2019	Exploring views of healthcare professionals, researchers, and people living with and beyond colorectal cancer on a healthy-eating and active lifestyle resource	1
Stacey, F. G.; James, E. L.; Chapman, K.; Lubans, D. R.	2016	Social cognitive theory mediators of physical activity in a lifestyle program for cancer survivors and carers: Findings from the ENRICH randomized controlled trial	4
Stevinson, C.; Fox, K. R.	2005	Role of exercise for cancer rehabilitation in UK hospitals: A survey of oncology nurses	1
Stuecher, Katrin; Vogt, Lutz; Niederer, Daniel; Banzer, Winfried; Schmidt, Katharina; Bolling, Claus; Dignaß, Axel	2019	Exercise improves functional capacity and lean body mass in patients with gastrointestinal cancer during chemotherapy: A single-blind RCT	2
Sutton, Eileen; Hackshaw-McGeagh, Lucy; Aning, Jonathan; Bahl, Amit; Koupparis, Anthony; Persad, Raj; Martin, Richard; Lane, J.; Hackshaw-McGeagh, Lucy E.; Martin, Richard M.; Lane, J. Athene	2017	The provision of dietary and physical activity advice for men diagnosed with prostate cancer: A qualitative study of the experiences and views of health care professionals, patients and partners	1
Talbot Rice, Helena; Malcolm, Lorna; Norman, Kate; Jones, Alison; Lee, Katherine; Preston, Gail; McKenzie, David; Maddocks, Matthew	2014	An evaluation of the St Christopher's Hospice rehabilitation gym circuits classes: Patient uptake, outcomes, and feedback	4
Thorsen, Lene; Skovlund, Eva; Strømme, Sigmund B.; Hornslien, Kjersti; Dahl, Alv A.; Fosså, Sophie D.	2005	Effectiveness of physical activity on cardiorespiratory fitness and health-related quality of life in young and middle-aged cancer patients shortly after chemotherapy	2
Truong, Pauline T.; Gaul, Catherine A.; McDonald, Rachel E.; Petersen, Ross B.; Jones, Stuart O.; Alexander, Abraham S.; Lim, Jan T. W.; Ludgate, Charles	2011	Prospective evaluation of a 12-week walking exercise program and its effect on fatigue in prostate cancer patients undergoing radical external beam radiotherapy	2
Tsianakas, Vicki; Harris, Jenny; Ream, Emma; Van Hemelrijck, Mieke; Purushotham, Arnie; Mucci, Lorelei;	2017	CanWalk: A feasibility study with embedded randomised controlled trial pilot of a walking	4

Green, James S. A.; Fewster, Jacquetta; Armes, Jo		intervention for people with recurrent or metastatic cancer	
Veal, I.; Peat, N.; Jones, G. D.; Tsianakas, V.; Armes, J.	2019	Missed opportunities for physical activity management at key points throughout the chemotherapy pathway for colorectal survivors: An observational interview study	1
Young-McCaughan, Stacey; Mays, Mary Z.; Arzola, Sonya M.; Yoder, Linda H.; Dramiga, Stacey A.; Leclerc, Kenneth M.; Caton, John R.; Sheffler, Robert L.; Nowlin, Marilyn U.	2003	Research and commentary: Change in exercise tolerance, activity and sleep patterns, and quality of life in patients with cancer participating in a structured exercise program	3
Young-McCaughan, S.; Mays, M. Z.; Arzola, S. M.; Yoder, L. H.; Dramiga, S. A.; Leclerc, K. M.; Caton, J. R., Jr.; Sheffler, R. L.; Nowlin, M. U.	2003	Change in exercise tolerance, activity and sleep patterns, and quality of life in patients with cancer participating in a structured exercise program...including commentary by Mock V	3
Young Ho, Yun; Young Ae, Kim; Myung Kyung, Lee; Jin Ah, Sim; Byung-Ho, Nam; Sohee, Kim; Eun Sook, Lee; Dong-Young, Noh; Jae-Young, Lim; Sung, Kim; Si-Young, Kim; Chi-Heum, Cho; Kyung Hae, Jung; Mison, Chun; Soon Nam, Lee; Kyong Hwa, Park; Sohee, Park; Yun, Young Ho; Kim, Young Ae; Lee, Myung Kyung	2017	A randomized controlled trial of physical activity, dietary habit, and distress management with the Leadership and Coaching for Health (LEACH) program for disease-free cancer survivors	2
Ying, Wang; Min, Qiang Wan; Lei, Tang; Na, Zheng Xiao; Li, Li; Jing, Li	2019	The health effects of Baduanjin exercise (a type of Qigong exercise) in breast cancer survivors: A randomized, controlled, single-blinded trial	2
Yang, Tsui-Yun; Chen, Mei-Ling; Li, Chia-Chun	2015	Effects of an aerobic exercise programme on fatigue for patients with breast cancer undergoing radiotherapy	2
Yochem, A.; Adams, B. E.; Minick, K.; Brennan, G. P.	2018	A standardized physical therapy cancer rehabilitation protocol in acute care for patients with haematological malignancies	2
Wonders, Karen Y.; Wise, Rob; Ondreka, Danielle; Gratsch, Josh	2019	Cost savings analysis of individualized exercise oncology programs	3
White, S. M.; McAuley, E.; Estabrooks, P. A.; Courneya, K. S.; White, Siobhan M.; McAuley, Edward; Estabrooks, Paul A.; Courneya, Kerry S.	2009	Translating physical activity interventions for breast cancer survivors into practice: An evaluation of randomized controlled trials	1
Webb, J.; Peel, J.; Fife-Schaw, C.; Ogden, J.	2019	A mixed methods process evaluation of a print-based intervention supported by internet tools to improve physical activity in UK cancer survivors	1
Webb, J.; Fife-Schaw, C.; Ogden, J.	2019	A randomised control trial and cost-consequence analysis to examine the effects of a print-based intervention supported by internet tools on the physical activity of UK cancer survivors	1
Wenzel, Jennifer A.; Griffith, Kathleen A.; Shang, Jingjing; Thompson, Carol B.; Hedlin, Haley; Stewart, Kerry J.; DeWeese, Theodore; Mock, Victoria	2013	Impact of a home-based walking intervention on outcomes of sleep quality, emotional distress, and fatigue in patients undergoing treatment for solid tumors	2
Wang, Ya-Jung	2010	Effects of a six-week home-based walking program on Taiwanese women newly diagnosed with early stage breast cancer	2
Vanlemmens, L.; Anota, A.; Bogart, E.; Nerich, V.; Cauchois, D.; Dewitte, A.; Dormeuil, E.; Lartigau, E.; Le Gall, F.; Mocaer, H.; et al.,	2019	eMouvoir: Randomized study estimating the impact of a personalized and remote support centered on physical activity (PA) for patients (pts) after breast cancer (BC)	2
van der Leeden, Marike; Balland, Chloé; Geleijn, Edwin; Huijsmans, Rosalie J.; Dekker, Joost; Paul, Marinus A.; Dickhoff, Chris; Stuiver, Martijn M.	2019	In-hospital mobilization, physical fitness and physical functioning following lung cancer surgery	3

van, Rooijen Stefanus; Molenaar, Charlotte J. L.; Schep, Goof; van Lieshout, Rianne; Beijer, Sandra; Dubbers, Rosalie; Rademakers, Nicky; Papen-Botterhuis; Nicole E.; van Kempen Suzanne; Carli, Francesco; Roumen, Rudi; Slooter, Gerrit.	2019	Making patients fit for surgery: Introducing a four pillar multimodal prehabilitation program in colorectal cancer	2
Veal, I; Peat, N.; Jones, G. D.; Tsianakas, V.; Armes, J.	2019	Missed opportunities for physical activity management at key points throughout the chemotherapy pathway for colorectal survivors: an observational interview study	1
von Gruenigen, Vivian; Frasure, Heidi; Kavanagh, Mary Beth; Janata, Jeffrey; Waggoner, Steven; Rose, Peter; Lerner, Edith; Courneya, Kerry S.	2012	Survivors of uterine cancer empowered by exercise and healthy diet (SUCCEED): A randomized controlled trial	2
Umstattd Meyer, M. Renée; Meyer, Andrew R.; Wu, Cindy; Bernhart, John	2018	When helping helps: exploring health benefits of cancer survivors participating in for-cause physical activity events	3
Ungar, Nadine; Tsiouris, Angeliki; Haussmann, Alexander; Herbolsheimer, Florian; Wiskemann, Joachim; Steindorf, Karen; Sieverding, Monika	2019	To rest or not to rest-Health care professionals' attitude toward recommending physical activity to their cancer patients	1
Vallance, Jeff; Lesniak, Susanne L.; Belanger, Lisa J.; Courneya, Kerry S.	2010	Development and assessment of a physical activity guidebook for the Colon Health and Life-Long Exercise Change (CHALLENGE) trial (NCIC CO.21)	1
Vallance, Jeffrey Kelcey Hayes	2008	Promoting physical activity in breast cancer survivors: A randomized controlled trial	2
Vallance, Jeff K.; Nguyen, Nga H.; Moore, Melissa M.; Reeves, Marina M.; Rosenberg, Dori E.; Boyle, Terry; Milton, Shakira; Friedenreich, Christine M.; English, Dallas R.; Lynch, Brigid M.	2019	Effects of the activity and technology (activate) intervention on health-related quality of life and fatigue outcomes in breast cancer survivors	1
van Gemert, Willemijn A. M.; van der Palen, Job; Monninkhof, Evelyn M.; Rozeboom, Anouk; Peters, Roelof; Wittink, Harriet; Schuit, Albertine J.; Peeters, Petra H.	2015	Quality of life after diet or exercise-induced weight loss in overweight to obese postmenopausal women: The SHAPE-2 randomised controlled trial	3
van Waart, Hanna; Stuiver, Martijn M.; van Harten, Wim H.; Geleijn, Edwin; Kieffer, Jacobien M.; Buffart, Laurien M.; de Maaker-Berkhof, Marianne; Boven, Epie; Schrama, Jolanda; Geenen, Maud M.; Meerum Terwogt, Jetske M.; van Bochove, Aart; Lustig, Vera; van den Heiligenberg, Simone M.; Smorenburg, Carolien H.; Hellendoorn-van Vreeswijk, Jeannette A. J. H.; Sonke, Gabe S.; Aaronson, Neil K.	2015	Effect of low-intensity physical activity and moderate- to high-intensity physical exercise during adjuvant chemotherapy on physical fitness, fatigue, and chemotherapy completion rates: Results of the PACES randomized clinical trial	2
van Waart, Hanna; van Dongen, Johanna M.; van Harten, Wim H.; Stuiver, Martijn M.; Huijsmans, Rosalie; Hellendoorn-van Vreeswijk, Jeannette A. J. H.; Sonke, Gabe S.; Aaronson, Neil K	2018	Cost-utility and cost-effectiveness of physical exercise during adjuvant chemotherapy	2
Zopf, Eva M.; Bloch, W+A127:D134ilhelm; Machtens, Stefan; Zumbé, Jürgen; Rübben, Herbert; Marschner, Stefan; Kleinhorst, Christian; Schulte-Frei, Birgit; Herich, Lena; Felsch, Moritz; Predel, Hans-Georg; Braun, Moritz; Baumann, Freerk T.	2015	Effects of a 15-month supervised exercise program on physical and psychological outcomes in prostate cancer patients following prostatectomy: The ProRehab study	3

Supplementary Table 5: Summary of results Implementation Outcomes

Review	Year	Assessment tool/metric	Main Findings	Synthesis
Acceptability				
Kirkham	2018	Survey	Overall satisfaction was high. Positive results were reported for ease of attending sessions, clear program expectations, feeling supported, belief that they could continue with lifestyle changes and would recommend the program to others	90.5% (n=5) acceptability; satisfaction rated as high
Leach	2015	Self-reported	96.2% enjoyed the program and 89.8% looked forward to attending exercise sessions	
Muraca	2011	Survey	83.3% rated the program as valuable and useful	
Rajotte	2012	Survey	Satisfaction with the classes was high, with all evaluation components above 95%	
Santa Mina	2019	Survey	General program satisfaction was high: 85% of respondents strongly agreed with statements of enjoyment, support of healthy behaviours, increased ability for activities of daily living, comfort with asking questions and appropriateness of the exercise prescription	
Sherman	2010	Survey	Overall satisfaction was high. Mean satisfaction rating of 28.16 (SD = 3.86) (maximum score 30) (94%)	
Adoption				
Beidas	2014	Barriers and enablers	*Barriers* - Variability in program costs covered by insurance, group-based structure is difficult with patient population, the cost to patients, labour intensive and confusing referral process, provider's ability to determine patient eligibility *Enablers* - Established champion role, adapting the program (which included training staff to help with individualising programs, establishing a staff liaison role to coordinate referrals and calling patients who had been referred to confirm attendance at pre-program assessment. This phone call increased the portion of women who undertook the pre-program assessment from 39% to 65%)	Barriers - Cost (programs not subsided, implementation costs and costs to participants), low or cumbersome process for referrals, competing time demands of staff, lack of community resources to support ongoing activity, individual stage of change Enablers - Champion, staff training to support individualised programming, dedicated role to optimising referrals, accessible location, simplifying assessment processes, referrals and delivery, ongoing evaluation during implementation to
Bultijnck	2018	Organisation adoption + barriers and enablers	65% of hospitals in Belgium had adopted exercise rehabilitation programs for cancer *Barriers* - Low referral rate (19%)	
Dalzell	2017	Barriers and enablers	*Barriers* - Competing demands of staff, lack of community resources to support the transition to self-management, bottlenecks in the referral process *Enablers* - Interaction between the medical team and program staff having access to medical charts	
Dennett	2017	Healthcare provider barriers and enablers	*Barriers* - Referral process (particularly when clinicians are not co-located at the same site), insurance coverage of patients, location (car parking and travel distance), the timing of programs, funding for equipment and advertising *Enablers* - Utilising multi-disciplinary services within other departments and in the community to meet complex patient needs, clinicians advocating for the program	
Haas	2011	Organisation adoption	14 sites have adopted FitSTEPS for Life across Dallas and Texas	
Heston	2015	Organisation adoption	416 sites have adopted LiveStrong YMCA across America	

Irwin	2017	Organisation adoption	18% of YMCA have adopted LiveStrong at the YMCA	address administrative barriers to participation, community partnerships, using evidence to support program buy-in, extensive education resources
Kimmel	2014	Barriers and enablers	*Enablers* - Accessible location (not gymnasium), establish a role to optimise referrals and negate the need for clinicians to explain the program/benefits of exercise	
Leach	2014	Barriers and enablers	*Barriers* - Sourcing funding, oncologist time to discuss referral with potential patients *Enablers* - Support from non-for-profit, cooperation and collaboration with local doctors, hospitals, cancer centres and other community organisations	
Rogers	2019	Barriers and enablers	*Barriers* Cost – participant costs (transportation costs, equipment (including clothing, childcare, gym fees) and other implementation costs (i.e., trainer certification, collecting and managing program data) Stage of change – mental health as a barrier to being active *Enablers* Engagement - communication between cancer survivors and leaders to encourage and educate participants and the local community, healthcare provider support and referrals, leveraging individuals who champion the program, building community partnerships, enhancing buy-in via communicating program benefits Reflecting and evaluating – documenting health measures as a record of implementation quality Design quality and packaging - creating a program that encouraged support among participants Cost - offsetting costs through charitable donations, grants and fundraisers Evidence strength and quality - using research and participant testimonials to motivate participants and convince stakeholders of program benefits Adaptability – programs should be adaptable (tailored) to patient needs, including scheduling options and type of activity Complexity – make the program easy to enrol in and implement. Make it initially easy for the patient to master exercise Implementation readiness – educational resources (training modules, cheat sheets, intervention delivery scripts), practical cancer-specific training and observation of others to support delivery staff. Further, proper funding, staffing, training resources, telephone and community engagement were identified as important during implementation. Organisational resourcing is important during program initiation but sustaining the program would require outside support (philanthropic) Implementation climate - informing the community (especially cancer survivors) about the importance of exercise to facilitate program acceptance Structural characteristics – the organisation paying for patients and transportation to their doctors Patient need and resourcing – be cognisant of childcare needs, lack of exercise and nutrition knowledge, costs, socioeconomic status, and cancer-specific exercise modifications Cosmopolitan - connecting with local retailers, religious organizations, fitness centres and rehabilitation facilities to provide supplies, funding, facilities and other types of support Knowledge and beliefs – address declines in participant motivation through accountability and social support	
Santa Mina	2012	Barriers and enablers	*Enablers* - accessible location, collegial support	

Santa Mina	2019	Barriers and enablers	*Enablers:* reduced volume of clinical questionnaires, changed healthcare professional undertaking initial assessment to reduce duplication for patients. Ongoing evaluation during implementation addressed numerous administrative and logistical barriers that increased participation between pilot and roll-out from 44% to 83%, respectively	
Sherman	2010	Organisation adoption	YWCA Encore delivered across 40 metropolitan and regional sites in Australia	
Wurz	2013	Barriers and enablers	*Enablers* - training instructors and resources (DVD (for patients)), evidence-based manual (for staff)), support from the local community and continuous program evaluation, tailoring exercise	
			Appropriateness	
Review	**Year**	**Assessment tool/metric**		**Synthesis**
Beidas	2014	Previous efficacy study completed	The intervention was revised with oncology clinicians, physical therapists and survivors to improve the feasibility in practice. The modifications to the program were documented	
Bjerre	2018	Previous efficacy study completed	Previous completion of a small-scale explanatory randomized controlled trial demonstrated promising findings. Based on these findings, this study examined the real-world effectiveness of the intervention when delivered using pre-existing infrastructure	Most studies demonstrated appropriateness of exercise interventions by building on a preliminary efficacy study in the same population.
Bjerre	2019	Previous efficacy study completed	FC Prostate Community was launched based upon positive findings in a small-scale exploratory randomised control trial	
Culos-Reed	2018	Scoping review + review of established programs + community consultation	An initial scoping review of existing programs, resources and literature for lifestyle programs for prostate cancer. This included review of protocols for established programs and outreach to professionals operating existing programs and industry-led workshops	
Dolan	2018	Previous efficacy study completed	The Health, Exercise, Active Living, Therapeutic lifestyle (HEALTh) program evolved from a pilot study and uses the pre-existing cardiac rehabilitation framework for its structure	
Kirkham	2018	Previous efficacy studies completed within same population + implementation barriers	The design considered four previous randomised control trials in the same population and identified barriers and enablers to implementation	
Kirkham	2019	Previous efficacy studies completed within same population + implementation barriers	The design considered previous randomised control trial and effectiveness results compared to the efficacy study	
Mackenzie	2013	Previous efficacy study completed	The Yoga Thrive program is a research-based, 7-week therapeutic yoga program that has been pilot-tested in both breast and prostate cancer patients	
Rajotte	2012	Initial 12 months of program refinement	The first year of the program implementation focused on developing and refining the training curriculum and program, determining effective and safe criteria for program eligibility, and training staff. The current study focuses on data collected during years two and three	
Rogers	2019	Previous efficacy study completed	Efficacy established through a previous trial, the program is now being adapted for implementation and dissemination	
Santa Mina	2019	Pilot phase before roll-out	From April 2014 to July 2015 a pilot phase of the program was run before the ongoing roll-out	

Swenson	2014	Program based on an established model of care	Program based upon Cancer Survivorship Model of Care and training provided by Rocky Mountain Cancer Rehabilitation Institute	
VanGerpen	2013	Previous literature + established model + program staff	Program development used an established cardiac rehabilitation model, coupled with a literature review and program delivery staff	
Cost				
Beidas	2014	Intervention cost	A hybrid model of self-payment (US$416.50), co-payments (range US$0-$80 per session) or a combination	Organisation – initial implementation cost approx. $US45, 000 (2018). The source of funding varies between donations, fundraising, and research grants. Hybrid models of intervention funding including; non-for-profit donations, fee-for-service models and co-payment from participant
Bjerre	2018	Intervention cost	The cost of delivering the FG intervention was $US46,213	
Culos-Reed	2018	Intervention cost	The initial 12 weeks is no charge and then the maintenance phase applies a fee-for-service model	
Culos-Reed	2019	Intervention Cost	The initial 12 weeks is no charge and then participants paid CA$99 per subsequent 12-week session	
Dalzell	2017	Organisation cost	Organisation - private donations, targeted fundraising events and research grants	
Haas	2011	Organisation cost + intervention cost	Organisation - initial start-up costs were covered by a financial commitment from all oncology providers in the community. Additional support from Lance Armstrong Foundation and local business people who provided treadmills at cost. Intervention – no cost to individuals	
Heston	2015	Organisation cost + intervention cost	Organisation - supported by not-for-profit Intervention – no cost to individuals	
Kirkham	2016	Intervention cost	Intervention costs $300 (approximately 50% of participants receive a scholarship to complete the program)	
Kirkham	2018	Organisation cost + intervention cost	Organisation - Annual costs include start-up $US3,055, personal $US40,906, program $US860, Total (1st year) $US44,821 (subsequent years) $US41,766	
Marker	2018	Intervention cost	$59/month to cover facility membership	
Rogers	2019	Organisation cost	Variable based on location, however, implementation cost reported being $350 per person	
Santa Mina	2012	Organisation cost + Intervention cost	Organisation - hospital foundation and fundraising initially covered the cost. A cost-recovery model was implemented to cover ongoing expenses, which also includes donations from participants	
Feasibility				
Bjerre	2018	Adherence rate	64% attendance at sessions (12 weeks) 59% attendance at sessions (6 months)	Attrition ranged between 56% - 22%. Total mean attrition rate was 38.8% (n=9) and 38.4% (n=7) for unique programs (patients discontinuing the program),
Brown	2019	Adherence rate + attrition rate	80% mean attendance rate; 56% attrition rate	
Cheifetz	2014	Attrition rate	44% attrition rate	
Cheifetz	2015	Attrition rate	26% attrition rate (and 85.4% continued to exercise after completion of the program)	

Culos-Reed	2018	Adherence rate	40.3% attendance rate (average across class types)	Attendance ranged between 83% - 30%. The total mean attendance rate was 61.6% (n=16) and 63.7% (n=15) of unique programs (number of attended sessions)
Dolan	2018	Adherence rate	66.6% attendance rate	
Haas	2011	Attrition rate	50% attrition rate, a phone call was implemented to support participant’s engagement, and this decreased the attrition rate to 30%	
Haas	2012	Attrition rate	40% attrition rate at 6 months	
Heston	2015	Attendance rate	79% attendance rate at sessions	
Irwin	2017	Attendance rate	83% attendance rate at sessions	
Kimmel	2014	Attrition rate	The attrition rate is ~45%	
Kirkham	2016	Attrition rate	45% attrition rate	
Kirkham	2018	Adherence rate + attrition rate	22% attrition rate, 54% attendance rate (average across program phases)	
Leach	2015	Attendance rate	31% attendance rate at sessions	
Leach	2016	Attendance rate	62.5% attendance at sessions (12 weeks) 30% attendance at sessions (24 weeks)	
Mackenzie	2013	Attendance rate	72% attendance rate at sessions	
Marker	2018	Attendance rate	62% attendance rate at sessions	
Noble	2012	Attrition rate	31% attrition rate	
Santa Mina	2017	Attendance rate	56% attendance rate at sessions (average across total program)	
Sherman	2010	Adherence rate	82.5% attendance rate	
Speed-Andrews	2012	Attendance rate	63.9% attendance rate	
Fidelity				
Bjerre	2018	Likert scale	The football coach’s fidelity to the intervention manual was 3.8 (3.7–3.9), where 1 was non-adherence and 5 was perfect adherence. Eight hours of training	
Brown	2019	Descriptive report of training	The program is delivered by Clinical Cancer Exercise Specialists certified by the University of Northern Colorado Cancer Rehabilitation Institute. They receive over 500 hours of training and patient contact and were certified by a written examination and practical evaluation.	
Cheifetz	2014	Descriptive report of training	Staff received 12 hours of training and received ongoing, onsite mentoring by nurses and physiotherapists	Adherence to the intervention protocol was approx. 76% (n=1). Quality of program
Culos-Reed	2018	Descriptive report of training	Quality of program delivery was complemented by cancer and exercise training, including online (21 hours) and in-person (8 hours) training	

Heston	2015	Descriptive report of training	Staff undergo training to achieve certification as a LIVESTRONG® at the YMCA instructor (up to 47 hours)	delivery was assured through staff training (n=5)
Santa Mina	2017	Descriptive report of training	Quality of program delivery is complemented by staff undergoing compulsory training in exercise and cancer (8 hours)	
Penetration				
Kirkham	2018	Referral rate	Referral rate - 53%	Referral rate 53%(n=1)
Sustainability				
Haas	2012	QOL - SF-36 + barriers and enablers	Significant improvement in physical (F=2.33; p=0.031) and mental (F= 3.36; p=0.003) components of SF-36 over time. The sustainability of the program was reported (in part) due to a phone call made by the Clinical Director to schedule the initial visit and train staff monitoring participants	Health outcome (QOL) was sustained over time, supported by the clinical director role and trained staff (n=1)

Chapter 5: **Czosnek L**, Zopf E, Cormie P, Rosenbaum S, Richards J, Rankin N. Developing an implementation research logic model: Using a multiple case study design to establish a worked exemplar. *Implementation Science Communications*. 2022; 3(90). doi.org/10.1186/s43058-022-00337-8

Additional file 1: Standards for Reporting Qualitative Research (SRQR)

O'Brien B.C., Harris, I.B., Beckman, T.J., Reed, D.A., & Cook, D.A. (2014). Standards for reporting qualitative research: a synthesis of recommendations. *Academic Medicine, 89(9)*, 1245-1251.

No. Topic	Item	Page number
Title and abstract		
S1 Title	Concise description of the nature and topic of the study identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	Page 1
S2 Abstract	Summary of key elements of the study using the abstract format of the intended publication; typically includes objective, methods, results, and conclusions	Page 2
Introduction		
S3 Problem formulation	Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	Page 4, 5 and 6
S4 Purpose or research question	Purpose of the study and specific objectives or questions	Page 7
Methods		
S5 Qualitative approach and research paradigm	Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., positivist, constructivist/interpretivist) is also recommended	Page 8
S6 Researcher characteristics and reflexivity	Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, or transferability	NA
S7 Context	Setting/site and salient contextual factors; rationale[a]	Page 8
S8 Sampling strategy	How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling	Page 9

	saturation); rationale[a]	
S9 Ethical issues pertaining to human subjects	Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	Page 22
S10 Data collection methods	Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale[a]	Page 9 and 10
S11 Data collection instruments and technologies	Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	Page 9 and 10
S12 Units of study	Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	Page 12
S13 Data processing	Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/deidentification of excerpts	Page 11
S14 Data analysis	Process by which inferences, themes, etc., were identified and developed, including researchers involved in data analysis; usually references a specific paradigm or approach; rationale[a]	Page 11
S15 Techniques to enhance trustworthiness	Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale[a]	Page 10,11
Results/Findings		
S16 Synthesis and interpretation	Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	Page 12
S17 Links to empirical data	Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	NA
Discussion		
S18 Integration with prior work, implications, transferability, and contribution(s) to the field	Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	Page 13 and 14
S19 Limitations	Trustworthiness and limitations of findings	Page 14
Other		

S20 Conflicts of interest	Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	Page 22
S21 Funding	Sources of funding and other support; role of funders in data collection, interpretation, and reporting	Page 22

[a]The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Chapter 6: **Czosnek L**, Rosenbaum S, Rankin N, Zopf E, Cormie P, Herbert B, Richards J. Implementation of physical activity interventions in a community-based youth mental healthcare service: A case study of context, strategies, and outcomes. *Early Interventions in Psychiatry*. 2022 June;1-11. doi.org/10.1111/eip.13324

Supplementary file 1: Definitions

<table>
<tr><th>Term</th><th colspan="2">Definition</th></tr>
<tr><td>Implementation</td><td colspan="2">The process of putting to use or integrating evidence-based interventions within a setting (Brownson et al., 2017)</td></tr>
<tr><td>Implementation research</td><td colspan="2">The scientific study of the use of strategies to adopt and integrate evidence-based health interventions into clinical and community settings to improve individual outcomes and benefit population health (National Institute Health, 2019)</td></tr>
<tr><td>Context</td><td colspan="2">Complex adaptive systems that form the dynamic environment(s) in which implementation processes are situated (May, 2013)</td></tr>
<tr><td>Implementation Strategy</td><td colspan="2">Methods or techniques used to enhance the adoption, implementation, and sustainability of a clinical program or practice (Powell et al., 2015)</td></tr>
<tr><td>Implementation outcomes</td><td colspan="2">The effects of deliberate and purposive actions to implement new treatments, practices, and services (Proctor et al., 2011)</td></tr>
<tr><td>Mechanism of change</td><td colspan="2">Process or event through which an implementation strategy operates to affect desired implementation outcomes (Lewis et al., 2018)</td></tr>
<tr><td colspan="3">Implementation outcomes of interest in this study</td></tr>
<tr><td></td><td>Definition</td><td>Operational application in this study</td></tr>
<tr><td>Acceptability</td><td>The perception among implementation stakeholders that a given treatment, service, practice, or innovation is agreeable, palatable, or satisfactory (Proctor et al., 2011)</td><td>Healthcare professional's perception of the PA intervention that was implemented in the organisation</td></tr>
<tr><td>Fidelity</td><td>The degree to which an intervention was implemented as it was prescribed in the original protocol or as it was intended by the program developers (Proctor et al., 2011)</td><td>Evidence of adherence to the PA protocol as measured by: 1) quality of program delivery (e.g., training/monitoring); and 2) dose or amount of program delivered and received (e.g., sessions/duration per week, total program delivered versus intended amount (delivered), attendance rates (received))</td></tr>
<tr><td>Penetration</td><td>The integration of a practice within a service setting and its subsystems (Proctor et al., 2011)</td><td>Evidence of organisational penetration within service system as measured by: 1) reach of PA intervention (e.g., young people participating in the PA program versus total number of young people eligible); and 2) integration within the subsystem as evidenced by organisational documentation that references PA services (e.g. staff manuals, positions descriptions, organisational budgets)</td></tr>
<tr><td>Sustainability</td><td>The extent to which a newly implemented treatment is maintained or institutionalized within a service setting's ongoing, stable operations (Proctor et al., 2011)</td><td>Sustainability of PA as evidenced by: 1) a process inplace that assures continued health benefits of PA; 2) maintenance of the core PA program components; and 3) evidence of the PA programs evolution over time</td></tr>
<tr><td colspan="3">PA = physical activity</td></tr>
</table>

Supplementary file 2: Study aims, constructs with corresponding measure and data source

Study aim	Construct	Measure	Data Source
1. How does a community-based mental health service successfully implement physical activity interventions within an EPP?			
Identifying context	Multi-level determinant analysis	Consolidated Framework for Implementation Research (CFIR)	Semi-structured interviews Document review
Implementation strategies	Implementation process	Expert Recommendations for Implementing Change (ERIC)	Combined data source
Implementation outcomes			
	Acceptability	How is the physical activity intervention perceived within the organisation?	Semi-structured interview
	Fidelity	Adherence to the program protocol with reference to dose/quality	
	Dose or amount of program delivered/received	# Sessions/duration per week # Total program delivered versus intended amount (delivered) # Attendance rates (received)	Document review
	Quality of program delivery	Evidence of training/monitoring to support quality delivery	Document review Semi-structured interview
	Penetration		
	Integration into service setting	Reach - number of eligible people who use the service/total number eligible	Document review
	Integration into subsystems	Evidence of integration within organisational routines and policy, procedures # documented position description where the intervention is defined in a role # budget that confirms funding # strategic planning that includes reference to the intervention	Document review Semi-structured interview
	Sustainability		
	Continued health benefit	Process in place to measure continued health benefits to young people	Document review data Semi-structured interview
	Continued program components	Program Sustainability Assessment Tool (PSAT)	PSAT and combined data source
	Evolution over time	PSAT	PSAT and combined data source
2. What learnings can be drawn from the case study findings?			
		Implementation research logic model	Combined data source
PSAT = Program sustainability assessment tool # = number			

Supplementary file 3a: Description and evidence of contextual factors in use within community-based youth mental health service

Domain	Construct	Detailed summary of construct extracted from framework matrix	Example	Valance/strength coding
Intervention	Intervention source	NA		
	Evidence strength and quality	Evidence and guidelines recommending prioritisation of physical health care, which includes lifestyle interventions, have increased in recent years.	"I know [organisation name] have done a lot of research in this area…. they have also generated some research about the value of having exercise physiology involved directly in a mental health service like ours" (Interview-07)	1
	Relative advantage	Referral to PA is the solution to address issues that arise from an abnormal screen (e.g., increased BMI, risk of weight gain associated with commencing medications).	"we are expected to do a lot of blood tests on people and find out whether they've got high risk of heart disease or stroke or are overweight, but then there is usually no mechanism to do anything about it. But it seems silly to just be screening people if you're not actually going to do anything about it. So, we thought the PA would be a good way. Obviously, a primary reason was to have PA as part of the suite of therapeutic (offerings), but also a way to manage better physical health" (Interview-01)	2
	Adaptability	The type of PA program delivered is continually adapted and evolving. The flexibility of delivery staff to tailor the PA program to the young peoples needs is viewed as important for program success.	"It was originally probably one to one, and then they had a group program, but it's just a continuing developing program" (Interview-02) "Our EP is really flexible and approachable in terms of what supports are offered. So it doesn't feel like "this is my model and this is what I can offer", she's really able to tailor it to what the clients looking for" (Interview-07)	2
	Trialability	NA		
	Complexity	Completing the physical health screen and engaging the AEP requires staff to dedicate extra sessions to this aspect of care. This is viewed as more work, however, the increased work involved has not been recognised by those implementing.	"because although people have said it's not more work, it is more work…. you basically have to do another session, or a couple of sessions that is focused on physical health" (Interview-06)	-2

	Design quality and packaging	Name changes and lack of unique branding mean the community cannot differentiate the EPP service from other services offered by the organisation.	"There is a need for a distinct brand for the program with community referrers often unaware of the difference…" (Document review)	-1
	Cost	Increasing resources for the PA services would mean reducing 'core' mental health services (i.e., case managers), as funding is capped.	"I think when the funding comes down to things, I think what they look at is those clinicians …that do all the case management side of things and kind of take a bit from the other side of things… so they're kind of in the background when it comes to those kind of things." (Interview-05)	-1
Outer setting	Patient need and resourcing	Youth participation is a core component of the program that is facilitated through advisory groups and built into the program's reporting structures.	A youth-friendly culture, reflected in attitudes, behaviours, décor, context and youth engagement is evident throughout all parts of the service (Document review)	2
	Cosmopolitan	The PA program operates by building partnerships and relationships with external partners.	"we collaborate with [sport club], which was awesome. So we were able to get a bunch of young people involved in a program, I think which was for about eight weeks. We also worked with [sport association] and we did a similar thing" (Interview-10)	2
	Peer pressure	(Organisational name) looked to successful sites interstate to mimic implementation of the service.	"..I don't know if you're familiar with the service in [interstate]. They're quite innovative and they led the way in this area…. And we've copied a lot of what they did to be honest."(Interview-01)	1
	External policy and incentives	The organisation's governance structure includes a collaboration with four other organisations, each having a separate function in the program's operations. This offers strong support yet also makes the governance complex.	"So I've got a lot of people we're accountable to, we're accountable to [organisation], were accountable to [organisation], we're accountable to [organisation] and [organisation] as well. So it's very confusing… I guess [organisation] are also interested to see how well we are integrated within all the other things that they're responsible for, including the state system" (Interview-01)	2
Inner setting	Structural Characteristics	The physical structure of the program means only one of the four sites has access to a gym space.	"Obviously, we share our sites with other teams and so space can sometimes be a bit of an issue. There is not a designated space for PA." (Interview-09)	-1

	Networks and communications	1. Opportunities to network across different health disciplines are facilitated and enable positive working relationships. Physical proximity appears to influence networking and communications, with some staff reporting the AEP role was less present within the team. 2. Personal relationships between staff create efficiencies in the workflow (i.e., simplify referral processes between staff to improve seamlessness for young people).	"I think just the ability to build relationships with other clinicians and case managers…A lot of the referrals I think I probably wouldn't get if I wasn't around and I wasn't seeing those people as regularly and having conversations with people and building those networks. It makes it a little bit tricky if your out of mind, people don't often think I could actually refer to an EP". (Interview-09) "So I think we're always talking. Yeah, communications pretty positive. And we do things like piggyback off session, so we try and make it so (people don't have) frequent appointments. So piggyback…" (Interview-06)	2
	Culture	1. Leaders see it as their ultimate responsibility to create an inclusive and supportive work environment. 2. Permeating all interactions with young people and their families is a culture that places their voice at the centre of all decision-making and how the organisation operates.	"I think (organisational name) has got quite a good culture generally because it's been primarily dreamed up because people weren't happy with the culture of the previous mental health system….." "ultimately though, my job is probably to try and set the culture of the service……" (Interview-01) "(Organisational name) feels very youth friendly. It feels quite open, quite vibrant and quite sort of energetic. And that translates over to the teams, I think." (Interview-03)	2
	Implementation climate	Between team differences exist regarding the completion of physical health screens and referral for PA.	"The completion rates across teams vary a lot. So, two of the teams are very much outstanding…. other teams have the majority of their clients whodon't have a physical health screen." (Interview-03)	-2

	Tension for change	*There is a reduced tolerance for accepting poor physical health and increased recognition that healthcare providers should be more accountable for this.*	*"So it's always been there. I just think over the last couple of years especially, more of a focus on the physical health of the young people" (Interview-05)* *"they probably realized that should have been doing it all along really" (interview-06)* *"The kind of outcry I suppose, about the fact that … you were prescribing these things to improve someone's mental health and you were completely neglecting or undoing their physical health" (Interview-02)*	*2*
	Compatibility	*PA services are provided by a small workforce, or solo positions, and so do not fit with traditional workforce models in mental healthcare services.*	*"But it's a lot more difficult because it is about finding the spot for them and in some ways an EP is a bit like a dietician. And in the old days, like a peer worker, you know, they could be solo positions or square pegs in a round hole" (Interview-01)*	*-1*
	Relative priority	*Physical health, and subsequently lifestyle issues such as PA and diet, are a 'nice to have' but not essential when dealing with an immediate crisis. Staff recognise this is not ideal and acknowledge the ongoing top-down priority on physical health.*	*"I mean, there's a lot going on in our team. Every day is pretty chaotic. And so I think physical health can often be one of those things that slips a bit in the discussions when you're dealing with kind of fairly extreme like homelessness or drug and alcohol and mental health to have that at the forefront of your mind." (interview-08)*	*-2*
	Organisational incentives and rewards	*The program is viewed as a leading, high-quality program that can be held up as a success. This provides an opportunity to assure program resources.*	*"we have a very good program because they can showcase us. So we make them look good. And they help us out a fair bit too and we can use that" (Interview-04)*	*1*
	Goals and feedback	*It was not clear to all staff what was expected with the introduction of physical health screening and thus referral for PA.*	*"…even quite senior people in our team sort of said that they didn't realize that they had to do it even though they were allied health... so they just quickly did all of their clients. And that was sort of only three months ago. So I think there's varying level of understanding as to what we're actually trying to capture and what's our priority around this stuff." (Interview-06)*	*-1*

	Learning climate	*Time and opportunity are provided for staff to engage in ongoing professional learning. A climate of evidence-based care and innovative practice is encouraged by leaders.*	*"My job is to try and protect our system from that culture of fear or blame. It's difficult…..so, trying to make (it a) better learning, supportive process rather than scrutinizing or blame finding process… and so what that (the blame finding process) has led to is more rigid authoritarian type practices, more restrictive practices on mental health clients and less innovation and less creativity in clinicians." (Interview-01)*	*2*
	Readiness for implementation	Responsiveness to physical health has fluctuated over the years. The organisation is currently in a period of peak attention, which appears to have coincided with the employment of a dedicated role (see *formally appointed internal implementation leader*)	"I feel like it ebbs and flows to be honest…. so I feel like it's maybe just having another go" (Interview-08)	-1
	Leadership engagement	*The leaders are engaged, supportive and driving the focus on physical health. They proactively identified a need to employ healthcare providers to address physical health.*	*"I feel like there's a real push from management… and it seems it's a big focus of mental health services. You hear that at the higher level. It's something that we're trying to have more of that preventative work" (Interview-08)* *"So once that sort of top down, you know, that support coming through makes it easy to sort of channel through the rest of the service." (Interview-07)*	*2*
	Available resources	*1. In comparison to most mental health services, the organisation is viewed as being well-resourced.* *2. The PA services are viewed as being spread thin due to the number of staff versus the number of site locations they visit. This means the PA service does not address identified operational barriers as quickly as it would like to due to the clinical contact taking priority.*	*"It's pretty well resourced to be honest. I've largely worked in homelessness and community-based agencies and (organisational name) is quite nicely resourced. So I suppose in comparison to that, yes, I feel like we are" (Interview-08)* *"And we are all aware that we don't have as much funding and as much FTE's as we would like to be able to really support the further development of these programs." (Interview-04)* *"I think the limitation at the moment is we have so much that we would like to improve … but … you need*	*1* *-2*

			the time to put these things in place, but we don't have that time… by the time you do meetings, reflect on some of the clinical work and putting those things in place, to actually change the processes is proving quite a challenge" (Interview-02)	
	Access to knowledge and information	*1. Some staff voiced a need for more information and training about physical health screening and diet/PA in mental health. This need existed despite evidence suggesting training and resources were supplied to support staff knowledge in this area.* *2. Most staff did not have a comprehensive understanding of what services the exercise physiologists offered but noted they could find out through the electronic medical records if needed.*	*"I think I could probably benefit from some more up to date knowing sort of what's happening with diet and PA trends" (Interview-06)* *"No, not that I'm aware of. I don't think we have had training, not that I have been a part of anyway….. But no formal training that I'm aware of for us on the ground." (Interview-07)*	*-1*
Individual	Knowledge and beliefs about the intervention	1. Staff suggested young people might be weary of engaging with the PA services because it may be viewed as another clinical service. This perception is thought to change with exposure. 2. Many healthcare professionals have had limited exposure to PA services within their working history, so don't understand what it is or what value it adds to the mental health treatment. Over time people come to see PA as a highly valuable part of the service. 3. Gaps continue to exist in the knowledge base, in that PA is only recognised for its role in addressing physical health issues and not for its direct impacts on mental illness.	"We kind of interact with people on a different level. And it's social and it's a bit fun and, you know, it's just like hobbies and sport. And their perception of what it could be changes" (Interview-02) They're really quite valuable and a lot of clinical staff have, they've come across to this program, and sort of realized the importance of (PA)" (Interview-04) "Once the case managers flag that someone isn't very active or that there is something on the physical health screen, they're quite good (at) reach(ing) out. I think we're still kind of trying to get there with the other elements, like as far as the mental health benefits. Ironically, (for a) mental health service we are really still trying to advocate for the benefits (of PA) on mood and like social connections." (Interview-02)	-2

	Self-efficacy	Some healthcare providers push back and state that it is outside their professional scope to complete physical screening. They lack confidence, don’t see it as their ‘core business’, are not sure they are asking the right questions and don’t know what to do with the results. Over time (and given there is an expectation that this is everyone’s business (see *leadership support*)) they have persisted and become more comfortable.	“I'm a (profession) by training so we don't have heaps to do with the physical space or the medical side of things.....I wouldn't feel comfortable doing that in terms of competence, but also as a (profession) it’s just out of our boundaries” (Interview-07) “But a lot of the rules within the (profession) and (profession) and (profession) won't allow the individual to do that....In (profession), for example. They don't see that as their core business.” (Interview-05) “Because it is not part of identity and what certain professions see as their responsibility.” (Interview-08) “I might ask this wrong or I don't feel comfortable asking this. I don't know what to do with the answers that I get.” (Interview-03) “Maybe just the more we do it, the more comfortable we are.” (Interview-06)	-2
	Individual stage of change	Healthcare staff have varied perceptions about how integrated PA was within their own clinical services. Some spoke of the role being part of the clinical team, while others saw them as a separate specialist service.	“So they do clinical work with us, …. I would then refer to the EP….then they would connect with the young person and follow them up if they need anything with physical health or PA and diet.” (Interview-05) “So for me, it's kind of been like "oh, it's really interesting, it's kind of like a bit of an additional thing" rather than being super integrated.” (Interview-10)	-2
	Individual identification with the organisation	A strong sense of community exists and identification with the ‘(organisation name) way’, meaning staff are passionate about their work and feel privileged to work at the site.	“We're really quite lucky… because it just attracts a lot of great people. So I really like (organisation name).” (Interview-10)	1
	Other personal attributes	Some healthcare professionals do not manage changes made to the physical health screening and referral process.	“So some people, I think can manage that flexibly, reasonably well. And some people I think maybe there's a rigidity of it's too specific or that it needs to	-1

			be that specific way. That it needs to be face-to-face and you need this to be checked." (Interview-03)	
Process	Planning	1. The document review identified that implementation was planned, and a process was undertaken to identify potential barriers and enablers. Some barriers that were identified in the planning documents are still reported as barriers in the bi-annual reports (see *design quality and packaging*). 2. There is a perception that including funding for the AEP at the start of the service was an enabler, as opposed to retrospectively seeking additional funding.	"We just stuck it in the budget, and no one questioned it" (Interview-01)	0
	Engaging	Case managers and management were viewed as the two groups that needed to be engaged for program success. Case managers because they have direct referral capacity and management because they are responsible for resource allocation.	"individual case managers and individual people who are giving you the referrals to have them on board, to have them understanding what you do or how you work with clients" (Interview-09) "always through management or the leadership team. My understanding is that those guys have been really supportive of this and getting it up." (Interview-07)	2
	Opinion leader	*NA*		
	Formally appointed internal implementation leader	*A nurse practitioner role was created to lead the physical health workflow and process.*	*I have organized to get a clinical practice nurse into our service, which has certainly helped a lot. And making the linkages between exercise physiology and sort of standard mental health so you can sort of see the link between." (Interview-04)*	*2*
	Champion	*Certain staff are viewed as driving the change (i.e., AEP, practice nurse, physical health special interest group). Each team has a representative on the physical health special interest group who is expected to then champion the service*	*"but there are champions of it and that is the EPs, the practice nurse and (the) physical health portfolio group" (Interview-02)*	*1*

		within their own team (n.b. implementation climate appears to influence this).		
	External change agents	*An external organisation with an established profile advocated for implementation and has an ongoing role to ensure implementation aligns with an established evidence-based model*	*"what we had to do was roll out a program that had fidelity to the (organisation name) model. (organisation name) had a role in determining and assessing whether the services were following the model correctly" (Interview-01)*	*2*
	Executing	NA		
	Reflecting and evaluating	1. Across the organisation, staff engage in an ongoing process of reflecting on and evaluating their work to improve services and outcomes. This is supported by a research officer who assists staff in planning evaluations. Of particular importance is gathering feedback from young people and their families to ensure the services meet their needs. Using data and documenting case studies of success is seen as valuable for reporting back to program funders and demonstrating demand for the program. 2. The program also exists within a broader network that collects outcome data using a consistent approach, however, this information does not get fedback to inform service delivery.	National resources include collection of a national minimum data set, which is routinely gathered from (organisation name) clients and service providers, and used to monitor and evaluate service activity and outcomes (Document review) "So we do a barbecue in our garden at the centre. And we invite young people, their families, parents, service providers, the staff at the centre (along). We use it as an opportunity to consultant around how our groups programs are going." (Interview-10) "we set up strategic surveys, like RedCap when we want to get some feedback that we can then use in a strategic way…. but anyway we can evaluate and highlight the need for more EFT and the value of having these programs, we try and do that." (Interview-04) "so it gets entered into a [database]…and so, the problem with that is it's very hard to get any information out of it". (Interview-01) "So we've been working with the research person, she is sort of the one that we've been talking with about this and she has helped us set it up. So I guess we sought advice from her about the best way to do that....We've been relying quite heavily on the use of Redcap. So we've been sending surveys out just to find	2

			out how people are finding the groups. And so do they have any ideas about what we could be doing, what they're enjoying, what's working, what's not working and that kind of thing… it just kind of like informing how we develop groups.” (Interview-10)	
	AEP = Accredited Exercise Physiologist, EP = Exercise Physiologist, FTE = Full-Time Equivalent, EPP = Early Psychosis Program, NA = Not Applicable, Italics = Indicates construct is a sibling within Consolidated Framework for Implementation Research (CFIR) framework, PA = Physical Activity			

Supplementary file 3b: Description of implementation strategies in use within community-based youth mental health service

Category	ERIC Strategy	Description of implementation strategy identified at the case site	Within category frequency
Adapt and tailor to context	Promote adaptability	Referrals are accepted through multiple mediums (i.e., email, verbal conversations) Multiple different types of physical activity are available for young people (i.e., walking groups, gym programs and sports) Teams and staff adapt to ensure the physical screen is completed, with staff developing their own systems to ensure completion	75%
	Tailor strategies	The strategy (*intervene with patients, consumers to enhance uptake and adherence*) is tailored to improve patient compliance. For example, the physical activity checklist has been moved from paper-based to electronic because staff identified paper-based information does not 'come back' from young people	
	Use data experts	A dedicated research position supports staff to conduct ongoing evaluations of the service and work	
	Use data warehousing techniques	NA	
Change infrastructure	Change accreditation or membership requirements	NA	42.80%
	Change liability laws	NA	
	Change physical structure and equipment	NA	
	Change record system	Physical activity services and physical screens are included in the online electronic record-keeping system. This includes a footer at the bottom of the physical health screening that prompts for referral to exercise physiology. This also acts as a strategy to 'remind clinicians' about the service	
	Change service sites	A central hub with connected but dispersed sites exists, which facilitates access to physical activity across more sites	

		and locations. Outreach visits are also conducted which brings the service to young people	
	Create or change credentialing and or licensure standards	NA	
	Mandate change	Organisational leaders declared physical health screening a priority	
	Start dissemination organisation	NA	
Develop stakeholder interrelations	Build a coalition	NA	37.30%
	Capture and share local knowledge	NA	
	Conduct local consensus decision	NA	
	Develop academic partnerships	An academic partnership facilitated initial funding and implementation of the service (via undertaking an advocacy role) and continues to be involved (via conducting fidelity reviews)	
	Develop an implementation glossary	NA	
	Identify and prepare champions	The exercise physiologist's role champions physical health, this is peer-to-peer advocacy	
	Identity early adopters	NA	
	Inform local opinion leaders	NA	
	Involve executive boards	Establish regular reporting requirements through governing organisations	
	Model and simulate change	NA	
	Obtain formal commitments	NA	
	Organise clinical implementation team meetings	NA	
	Promote network weaving	Staff have created their own multi-disciplinary team to provide holistic care and streamline services for young people. This negates the need for young people to engage in multiple, repeated appointments (the nurse and exercise physiologists work particularly closely and then engage with other teams)	
	Recruit, designate and train for leadership	NA	

	Use advisory boards and workgroups	Each service site has a youth advisory committee that ensures services are appropriate for youth and their families. They report to the executive and support service improvements (meet fortnightly)	
	Use and implementation advisor	NA	
	Visit other sites	Service is modelled on a successful program interstate	
Engage consumers	Increase demand	Physical activity is used as an *engagement tool* that helps engage young people in other support services	100%
	Intervene with patients, and consumers to enhance uptake and adherence	Multiple strategies are used to increase patient adherence to the physical activity programs including phone, emails and SMS (if sessions are missed), encouraging family and friends to attend sessions to increase social support, provision of Phyi-trak home programs	
	Involve patients' consumers and family members	Young people and their families are engaged at three levels (involved in decisions about their treatment, through the youth reference groups to improve service delivery and at a governance level to inform strategic planning)	
	Prepare patients and consumers to be active participants	A 'welcome' appointment is conducted, and a welcome pack (for physical activity) is used to support 'soft-entry' into the program Staff are trained to use an open dialogue approach to facilitate young people *choosing* what treatments and services they participate in	
	Use mass media	Social media (Instagram, Twitter and Facebook) are used to reduce stigma and raise awareness about the service	
Provide interactive assistance	Centralise technical assistance	NA	0%
	Facilitation	NA	
	Provide clinical supervision	NA	
	Provide local technical assistance	NA	
Support clinical teams	Create new clinical teams	A new role was created that is dedicated to improving the rates of physical screening across the service (i.e., nurse practitioner role)	80%

	Develop resource-sharing agreements	Informal agreements exist with a range of physical activity providers/services in the community (i.e., local sporting clubs, gyms an active recreation providers) to enable delivery and exposure to diverse physical activity opportunities for young people. Discounted rates for gym membership have been negotiated in some settings.	
	Facilitate relay of clinical data to providers	Clinical reviews are scheduled on a weekly basis, with the exercise physiologist 'dropping in' on meetings to relay clinical progress.	
	Remind clinicians	Constant efforts are made to remind other clinicians of the physical activity service (the exercise physiologist's attend existing team meetings to have informal 'corridor conversations' and disseminate internal staff emails to highlight events such as 'Exercise Right')	
	Revise professional roles	NA	
Train and educate stakeholders	Conduct educational outreach visit	NA	72.70%
	Conduct educational meetings	Whole-of-staff team meetings are held where presentations on physical activity services are delivered A one:one session is organised with new staff to meet the exercise physiologist and orientate them to the service	
	Conduct ongoing training	The organisation has a dedicated college that provides education courses. Staff and young people are encouraged to participate in courses. Courses about lifestyle interventions are delivered through this medium	
	Create a learning collaborative	A physical health special interest group (SIG) exists with representation from each team. The SIG share new evidence and reflects on how to improve screening. People in the SIG group are expected to champion physical health within their own teams	
	Develop educational materials	A staff manual exists that describes the physical activity services offered at the organisation together with all other services Resources about physical activity are available to staff and	

		used to prompt and 'remind clinicians' (i.e., flow chart of expectations around physical health, advice to break up sitting and signposting to online physical activity options)	
	Distribute educational material	Educational materials are distributed via organisation email blasts and to new starters as part of orientation	
	Make training dynamic	NA	
	Provide ongoing consultation	The junior exercise physiologist has regular meetings with the senior exercise physiologists to provide guidance and support	
	Shadow other experts	Initially staff worked in pairs to support each other in undertaking physical health screen	
	Use train-the-trainer strategies	A 'super-user' model has been established to train all staff in an open dialogue approach	
	Work with educational institutions	NA	
Use evaluative and iterative strategies	Assess for readiness and identify barriers and facilitators	Barriers and enablers to the successful implementation of the service were documented prior to initiating the service	60%
	Audit and provide feedback	An email is sent around on a weekly/fortnightly basis that identifies young people who require a physical health screen, based upon an audit of the full client list Independent fidelity visits are conducted to ensure the service is implementing the core components of the program	
	Conduct a local needs assessment	NA	
	Conduct cyclic small tests of change	NA	
	Develop a formal implementation blueprint	NA	
	Develop and implement tools for quality monitoring	Templates exist to guide initial assessment and exercise programming. Attendance is monitored through the electronic medical records	
	Develop and organise a quality monitoring system	A system has been created in Sharepoint that tracks who is referring and the reason for referral. This allows the exercise physiologist to strategically target teams/providers	

	Obtain and use patient, consumer, and family feedback	PROs (patient-reported outcomes, including satisfaction) are collected on an ongoing basis and fed to the executive for program reporting. Where specific information is required, strategic surveys are completed to support service improvements efforts	
	Purposely re-examine the implementation	Physical activity opportunities set for school terms that promote re-assessment Surveys are administered to young people after the introduction of new physical activity programs to ensure they meet the needs of young people	
	Stage implementation and scale-up	NA	
Use financial strategies	Access new funding	NA	11.10%
	Alter incentives allowance structures	NA	
	Alter patient, consumer fees	NA	
	Develop disincentives	NA	
	Fund and contract for the clinical innovation	NA	
	Make billing easier	NA	
	Place innovation on fee for service list	NA	
	Use capitated payments	NA	
	Other payment schemes	The service is commissioned through a contract with the government. This contract is time limited and reviewed on a regular basis.	

Supplementary file 4: The relationship between context, implementation strategies and implementation outcomes

Level	Context	Implementation strategy	Mechanism	Implementation outcome
Intervention (E)	Relative advantage (conditions identified that trigger referral to PA)	Change record system (PA in medical records)	Decision prompt at point of action	Sustainability
Intervention (E)	Adaptability (flexible approach to PA interventions)	Promote adaptability (develop and offer different types of PA, facilitated through using trained staff)	Ease and suitability	Acceptability
Intervention (B)	Complexity (screening for physical health is more work for case managers)	Create a new clinical team (add new staff member)	Capability building (increase dedicated resources so process and clinical workflows are streamlined)	Penetration (sub-system)
Outer (E)	Patient need and resources (engage service users in all aspects of service development and delivery)	Use advisory board and workgroups (youth advisory group established at all sites) Involve patients' consumers and family members (voice included in individual treatment, service delivery and strategic planning)	Fit for purpose	Acceptability
Outer (E)	Cosmopolitanism (partnerships with external PA opportunities)	Resource sharing agreement (partnerships with external gym/sports/discount fees negotiated)	Increase organisation resourcing and patient accessibility	Sustainability
Outer (E)	External policy and incentives (governance by multiple external agencies)	Develop and implement quality monitoring tools (templates to collect clinical and non-clinical data) Develop and organise a quality monitoring system (method to track who refers to PA) Involve executive boards (information collected through strategies above aggregated for reporting)	Conditions created for ongoing improvement – established goals/targets that drive actions	Fidelity (adherence to protocols) Penetration (sub-system) Sustainability
Inner (E)	Networks and communications (space to build trusted working relationships and discuss clinical care)	Facilitate relay of clinical data (EP drops in on clinical meetings)	Influences social connections and creates new social norms	Acceptability
Inner (E)	Culture (leaders create inclusive, supportive environment)	Bundles other strategies (mandate change, create new clinical team, create a learning collaborative, network, and communications)	Staff ownership	Acceptability, Penetration (sub-system), Sustainability (program components)
Inner (B)	Implementation climate (differences in physical health screening compliance between teams)	Audit and feedback (track completion of physical screen and report compliance)	Re-enforces desired behaviour	Penetration (service system)
Inner (E)	*Tension for change (poor physical health in people with mental illness has become untenable)*	*Mandate change (leaders outline expectations for physical health care)*	*Establishes an expected outcome*	*Acceptability*
Inner (B)	*Relative priority (physical health/PA is not the highest priority in clinical consultations)*	*Audit and feedback (track completion of physical screen and report compliance)*	*Re-enforces desired behaviour*	*Penetration (service system)*

Inner (E)	*Learning climate (provide an opportunity to learn across disciplines)*	*Create a learning collaborative (physical health SIG with representatives from all teams)*	*Reflective learning builds professional competency*	*Fidelity*
Inner (E)	*Leadership Engagement (executive buy-in for implementation)*	*Visiting other sites (expose leaders to best practices)*	*Modelling*	*Sustainability*
Inner (B)	*Available resources (overall the organisation is well-resourced, but the AEP service is spread thin)*	*Other payment schemes (commissioned service)* *Create a new clinical team (add new staff member)*	*Physical resources (human & financial)*	*Penetration (sub-system)* *Sustainability*
Individual (B)	Knowledge and beliefs about the innovation (limited exposure to PA through working history and lack of knowledge about PA and mental health)	Develop educational materials (manual details PA role and functions within organisation, flow chart) Conduct educational meetings (presentations through whole-of-staff meetings, one:one sessions for staff with AEP)	Building knowledge and awareness	Acceptability
Individual (B)	Self-efficacy (confidence and skills to conduct physical screening)	Shadow other experts (pair up to conduct screening)	Develops skill acquisition	Fidelity
Individual (B)	Individual stage of change (progression to full integration of PA)	Remind clinician (facilitate 'corridor' conversations, use 'educational material' to remind clinicians)	Facilitates intention to act	Acceptability ↓ Penetration (service system)
Process (E)	Engaging (leaders and case managers)	Bundle other strategies (visit other sites, mandate change, remind clinicians, create a learning collaborative)	Organisation process (social influences)	Acceptability, Penetration (service and sub-system), Sustainability
Process (E)	*Formally appointed internal implementation leaders (staff member identified to lead implementation)*	*Create a new clinical team (add new staff member)*	*Capability building (increase dedicated resources so process and clinical workflows are streamlined)*	*Penetration (sub-system)*
Process (E)	*External change agents (highly respected individual and organisation support implementation)*	*Create an academic partnership (formal partnership with a university)*	*Expertise, drive to implement*	*Fidelity (adherence to protocol)* *Penetration (sub-system)*
Process (E)	Reflecting and evaluating (data, opportunity, and capacity to evaluate progress on an ongoing basis)	Use data experts (skilled research staff support clinical workforce) Obtain and use patient, consumer, and family feedback (survey administered to collect feedback)	Justify demand/need Suitability	Fidelity Sustainment

AEP = Accredited exercise physiologist, B = Barrier, E = Enabler, PA = Physical activity, SIG = Special interest group, *Italics* = denotes construct is a child of another contextual determinant, ↓ = implementation outcome contributes to a secondary implementation outcome

Chapter 7: **Czosnek L**, Rankin N, Cormie P, Murnane A, Turner J, Richards J, Rosenbaum S, Zopf, E. *"Now is the time for institutions to be investing in growing exercise programs as part of standard of care"*: A multiple case study examining the implementation of exercise oncology interventions. Under review.

Supplementary file 1: Study aims, conceptualisation with operational measurement

Study aim	Conceptualisation	Operationalised measurement
Identify the commonalities and differences in determinants, implementation strategies and implementation outcomes (acceptability, fidelity, penetration, and sustainability) across exercise oncology services		
Identify determinants	CFIR	The CFIR framework lists 39 determinants across 5 domains and has an accompanying interview tool that was used to develop questions for the semi-structured interview guide that elucidated the determinants influencing implementation.
Identify implementation strategies	ERIC	The ERIC taxonomy lists 73 implementation strategies (including Additional file 6) and provided the description of implementation strategies identified and categorised through the study.
Identify implementation outcomes	IOF	The IOF is an evaluation framework that lists 8 proximal outcomes for measurement in implementation studies, of which 4 were evaluated in this study (see below).
	Acceptability - The perception among implementation stakeholders that a given treatment, service, practice, or innovation is agreeable, palatable, or satisfactory	Interview question - How do you think the exercise intervention is perceived within your organisation?
	Fidelity - The degree to which an intervention was implemented as it was prescribed in the original protocol or as it was intended by the program developers	Adherence to the program protocol according to amount and quality *Quality of program delivery* Training to support quality delivery *Amount of program delivered/received* # Sessions/duration per week # Total program delivered (delivered) # Attendance rates (received)
	Penetration - The integration of a practice within a service setting and its subsystems	*Integration in the service system* # Eligible people who use the service/total number eligible *Integration in the subsystems* # Documented position description where the intervention is defined in a role # Budget that confirms funding # Strategic planning that includes reference to the intervention
	Sustainability - The extent to which a newly implemented treatment is maintained or institutionalized within a service setting ongoing, stable operations	Sustainability is measured according to continued EBI components, the evolution of the EBI over time and process in place to assure continued health benefits *Continued program components* PSAT + Interview question: Are there any parts of the intervention that should not be changed? *Evolution over time* PSAT + Interview questions: Has what was implemented changed over time? What kinds of changes or alterations have been made to the intervention so it continues to work effectively in your setting? *Continued health benefit* Interview question: What type of objective health measures are taken before, during or after the program to monitor the patient's response to the exercise?
Develop an explanatory causal pathway for the implementation process from the common elements that exist across services		

Explain implementation	IRLM	A simplified IRLM was developed for each site and then the common elements identified across IRLMs were extracted, synthesised and reproduced in a single logic model
CFIR = Consolidated Framework for Implementation Research, EBI = Evidence-based Intervention, ERIC = Expert Recommendations for Implementing Change, IRLM = Implementation Research Logic Model, IOF = Implementation Outcomes Framework, PSAT = Program Sustainability Assessment Tool		

Supplementary file 2: Description of exercise evidence-based interventions implemented at case sites

	Case Site A	Case Site B	Case Site C (youth)	Case Site C (adult)
What (equipment)	Aerobic exercise (treadmill, seated rowing machine, exercise bike) Resistance training (free weights, machine weights, resistance bands)	Aerobic exercise (treadmill, exercise bike) Resistance training (free weights, machine weights)	Aerobic exercise (exercise bike) Resistance training (body weight, resistance bands, free weights)	Aerobic exercise (exercise bike) Resistance training (body weight, resistance bands, free weights)
Who (qualifications)	AEP	AEP + completion of cancer-specific training course (12 hours online training and 4–5-hour face-to-face workshop)	AEP	AEP and physiotherapists
How (delivery)	Group program (1 AEP per 5-6 participants)	Group program (1 AEP per 5-10 participants)	1:1 (during the active treatment phase) Group programs (within *optional* survivorship program)	Patient choice 1:1 session, home-based, or referral to a community provider Group sessions run 3x/week
When, how much (dosage)	12-week program (15 contact hours) 1x20 minute introduction + 1x1 hour initial assessment 1x1hr/week for 12 weeks 1x1 hour final assessment 1x20 minute review at 4 and 6 months Sessions include: 20 minutes aerobic exercise 30 minutes of resistance exercise (6-8 upper and lower body exercises) 10 minutes (group) stretching Nb: 7 different times for group classes are offered between Tuesday and Friday	12-week program (39 contact hours): 2x1 hour initial assessment 3x1 hour session per week (for 12 weeks) 1x1 hour final assessment Sessions include: 20 minutes of aerobic exercise 30 minutes of resistance (6 upper and lower body exercises (2-4 sets x 6-12 repetitions)) Nb: people select 1 of 5 sites to attend and are provided with a 3-month gym membership included in program cost	1:1 program Duration not set 1x30 minute initial assessment Session duration varies between 20 mins - 1 hour Sessions include: 20 minutes aerobic exercise 30 minutes of resistance exercise (8 upper and lower body exercises (2 sets x 10-12 repetitions) 10 minutes stretching *(preference is given to aerobic exercise when time is limited)* Group program 8-week program (16.5 contact hours) 1x30 minute initial assessment 2x1 hour sessions per week (1 hour exercise (content as per 1:1) + 1 hour education)	Duration not set 1x30 minute initial assessment Session duration varies between 20 mins - 1 hour duration (onsite) Re-assessment as required Onsite sessions include: 20 minutes aerobic exercise 30 minutes (8 upper and lower body resistance exercise (2 sets 10-12 repetitions) 10 minutes stretching *(preference is given to aerobic exercise when time is limited)*
Tailoring	Exercise EBIs are individualised. Adherence prompts (Physitrack* exercise sheets, walking checklist, use of fitness trackers or pedometers and exercise diaries)	Exercise EBIs are individualised. Adherence prompts (home program promoting 3x30 minute aerobic exercise per week)	Exercise EBIs are individualised. Adherence prompts for groups (custom-made app to track exercise, podcasts, videos, supports maintenance, fatigue and physical activity diaries)	Exercise EBIs are individualised. Adherence prompts (Simpleset* exercise program, education, fatigue and physical activity diaries)

Clinical assessment template	Template guiding initial assessment. Information captured: 1) referral source 2) cancer history 3) objective assessment (grip strength, 30-second sit-stand) 4) subjective measures including symptomology and patient goals, barriers and enablers to exercise, FACT-G 5) treatment recommendations	Template guiding initial assessment. Information captured: 1) pre-program questionnaire 2) prompt to 'develop rapport' 3) medical history 4) patient goals 5) objective assessment (height, weight, blood pressure, heart rate, 6-minute walk test, 30-second sit/stand) 6) treatment recommendations	Triage via HEEADSSS assessment framework. Initial assessment template (refer to Case site C (adult)	Template guiding initial assessment. Information captured: 1) medical history including cancer and lifestyle factors 2) assessment performance status (AKPS score and self-reported physical activity levels) 3) precautions for exercise 4) physical examination (height, weight, mobility, independence with transferring, resting heart rate, oxygen saturation and blood pressure), functional tests (6-minute walk test, grip strength, sit-to-stand test) 5) patient goals and objectives
Exercise session template	Template guides exercise session. Information captured: 1) name of exercise 2) weights, repetitions and sets for each resistance exercise 3) adherence and fatigue during session 4) prompts review of program every 2 weeks	Template guides exercise session. Information captured: 1) session number 2) name of exercise 3) weight, repetitions and sets for each resistance exercise 3) intensity of aerobic exercise 4) adherence and fatigue during session 5) prompts review of program every 2 weeks	Template guides exercise session. Information captured: 1) exercise type 2) intensity of aerobic exercise 3) heart rate/oxygen saturation 4) template captures up to 8 weeks of programming Program adherence is captured through EMR and not on exercise template	Template guides exercise session. Information captured: 1) aerobic and resistance exercise prescribed 2) intensity, frequency, duration, repetitions, and sets. Adherence to program captured after each session through EMR

AEP = Accredited Exercise Physiologist, AKPS = Australia-modified Karnofsky Performance Status, EMR = Electronic Medical Record, HEEADSSS = acronym for a comprehensive psychosocial assessment tool, FACT-G = Functional Assessment of Cancer Therapy – General, * = Physitrack and Simpleset are exercise software packages

Supplementary file 3: Descriptive example of determinants that were different across sites, identified using the Consolidated Framework for Implementation Research

Domain	Construct	Description of determinant	Example
Intervention	Intervention source	NA	
	Complexity	Two sites had implemented a centralised and streamlined referral process (i.e., through electronic medical record and a bespoke IT system) that sought to address complexity. One site identified the referral processes to exercise as *more work*.	*"Soon as that referral comes, it comes in through (an IT system), which centralizes everything into a single point contact for those guys." (Int-09)* *"But because it's a change to routine practice because it's an extra element now added into a consultation." (Int-02)*
	Design quality and packaging	One site had created a consistent brand and image for marketing the exercise EBI, which added to its perceived excellence. By contrast, the lack of packaging and bundling of the program for use was viewed as a barrier at another site.	*"And then obviously people were looking at the website and going this program looks great." (Int-06)*
	Cost	One site had costed the EBI ($1000.00AUD) and embedded this knowledge within how the service was implemented/funded and delivered.	*"So the cost is a thousand dollars. We try and fundraise to subsidise that cost so that we can provide access to as many patients as possible." (Int-09)*
Outer setting	Peer pressure	Two sites viewed their organisation as a *world leader* that set an agenda for other organisations. One site saw exercise EBIs as the *norm*, resulting in rapid implementation across the healthcare setting.	*"Everyone we meet every day knows about (organisational name)." (Int-04)*
Inner setting	Structural characteristics	Exercise EBIs were limited by the size of the allocated room and the equipment available. Further, two sites reported the organisational reporting line for exercise EBI was wrong and created barriers to implementation. By contrast, one site planned and selected sites based on specific criteria (i.e., parking, close to public transport, coffee shop and a range of equipment).	"*We have a dedicated gym space. Again, probably would like different pieces of equipment. Some of its more geared to sort of acute rehab, which don't really get seen, so... in hindsight, you wouldn't need that space, whereas capacity for exercise has really grown in that space and demand, you would probably change how you allocate space." (Int-11)*
	Culture	Staff across sites expressed different opinions about organisational culture. Some expressed the view that culture was *poor*. Other sites saw their culture as supportive and collegiate.	"*I would divide it up, I think the (immediate team) are a fantastic team and we work really well together. I think we are very supportive of each other, and it is probably what keeps me coming to work each day. Bigger than that is the (oncology department culture) and that is less supportive. Then outside of that is just working in a (organisation name), and at the moment that is just cuts going left*

			right and centre, and (that is) not supportive." (Int-01)
	Tension for change	Tension for change was not high enough to force change in behaviour/practice that would facilitate integration of exercise in routine practice.	*"We grow as big as the organisation wants us to grow. So there's like gatekeeper issues there. And if we're not generating a lot of revenue for the organisation, there's limited incentive to grow that service." (Int-14)*
	Relative priority	Two sites reported that in busy, time-limited consultations healthcare providers make decisions about what is the highest priority for discussion at that time.	*"The clinical imperative at the time is perhaps to look at different things. It is not seen as ... clinical important at a particular time when the doctor may be seeing the patient." (Int-05)*
	Organisational incentives and rewards	At one site the service had recently won a prestigious award, and this was seen as something that could be leveraged by the exercise EBI to support implementation.	*"We have been lucky that it has picked up some accolades along the way." (Int-01)*
	Goals and feedback	NA	
	Readiness for implementation	At one site, staff expressed a view that the exercise EBI was unplanned and disorganised.	*"I think it's just very haphazard and I think that's more to do with what we are as (organisation name) and the location of our patients. I think that plays a huge role in terms of the service that we deliver and what patients can access." (Int-13)*
	Leadership engagement	Two sites observed that lack of supportive strategic leadership was a risk to the sustainability of exercise EBI (i.e., because leaders didn't understand and value the service they were less likely to see a need to resource it). By contrast one site viewed their leaders as highly committed and engaged in ensuring the success of the exercise EBI	*"Sometimes I think the decisions are made by not necessarily taking a macro approach...but rather it becomes so discipline specific that when there's funds available, it's sometimes who's got the loudest voice? Who's got the greater numbers?.. So I think that having, sometimes stronger executive leadership…clearer, overarching organisational strategy and goals, and ensuring that rather than just being in a document, that they translate down to our levels and that it should be a two-way process." (Int-14)*
Individual	Knowledge and beliefs about the intervention	Different views about exercise EBIs existed across organisations. Some viewed it as beneficial, whilst others had established ideas about which patients should be referred and would benefit.	*"It could also be the perception that different groups are more appropriate for exercise. It maybe be and I don't know this, but a younger woman with breast cancer is more likely to be referred than an older man with prostate cancer and other multiple co-morbidities and things like that." (Int-05)*
	Individual identification with the organisation	At one site staff demonstrated different levels of commitment to the organisation, which may have contributed to some sites being more successful than others. At other sites, staff expressed a view of feeling fortunate to work at the sites	*"No, it doesn't worry me. It doesn't worry me because I know I've got the safety net of another job." (Int-07)*

		given their reputation as *world-leader*.	
Process	Planning	One site undertook 12 months of planning prior to the launch. Other sites did not undertake systematic planning with the exercise EBIs growing opportunistically.	*"Yes and no. I guess in my mind this would go beyond the (research) study… but did I sit down 10 years ago and say as of now I want 1, 2 and 3 - no. But it was always I want more time for AEP, I want to be able to offer classes (and) increase the classes. Most of this has been in my head. At different times, yes we have had to write and say what we are planning and so I would have given some stats." (Int-03)*
	Engaging	Differential views existed across sites about who needed to be engaged. One site viewed the oncology team as most important because they gave patients *permission* to exercise. Other sites viewed middle management (who develop business cases) and nurses (who coordinate referrals) as the most important stakeholders	*"(The oncology team) they're the ones that push it in terms of encouraging their patients to do exercise, to engage in exercise and to give them permission to actually exercise." (Int-09)*
	External change agents	NA	
	Opinion leader	NA	
	Formally appointed internal implementation leader	NA	
	Executing	One site had established KPIs to track implementation progress. However, had not reviewed progress due to the impacts of COVID-19.	*"So I suppose we haven't had to measure ourselves against (KPIs) because we know that we just haven't done anything." (Int-09)*

AEP = Accredited Exercise Physiologist, AUD = Australian Dollar, EBI = Evidence-based Intervention, IT = Information Technology, KPIs = Key Performance Indicators

Supplementary file 4: Implementation strategies that differed or were not in use across sites, identified using the Expert Recommendations for Implementation Change taxonomy

ERIC strategy	Descriptive example
Adapt and tailor to context	
Tailor strategies	Two sites tailored referral processes. One site trialled multiple systems to determine the most effective approach (i.e., case management model, triaging, all staff participating in the initial assessments and a hybrid model of triage based on physical, education, social and health needs).
Use data experts	One site had established a dedicated research role to support evidence-informed care. The position assisted staff in establishing outcome measures for the services and undertaking rapid reviews for use in business cases.
Use data warehousing techniques	NA
Change infrastructure	
Change physical structure or equipment	Two sites had created new purpose-built spaces for their patients (i.e., a new bigger gym space and a *chill-out* space for patients that felt *non-medicalised*).
Change service sites	One site operated a *hub and spoke* model that ensured exercise sites were accessible for patients. A second site had moved to a purpose-built facility which allowed for more dedicated exercise space.
Start a dissemination organisation	One site established a not-for-profit organisation with the sole purpose of providing evidence-based exercise for people with cancer.
Change accreditation or membership requirements	NA
Change liability laws	NA
Create or change credentialing and or licensure standards	NA
Mandate change	NA
Develop stakeholder interrelations	
Build a coalition	One site engaged organisations and individuals with specific expertise to provide in-kind financial, legal and regulatory support. This assisted the organisation to meet its corporate requirements.
Use advisory boards and working groups	Two sites established advisory groups, with representation from consumers, to support implementation efforts. At one site the advisory group focused on supporting organisational governance. At the second site, the advisory group had a specific policy development role.
Visit other sites	Two sites conducted site visits to other organisations delivering exercise oncology services to support initial implementation efforts.
Capture and share local knowledge	NA
Conduct local consensus decision	NA
Develop an implementation glossary	NA
Identify early adopter	NA
Model and simulate change	NA
Obtain formal commitments	NA
Organise clinical implementation team meetings	NA
Recruit, designate and train for leadership	NA
Use and implementation advisor	NA
Engage consumers	

Provide interactive assistance	
Centralise technical assistance	One site had established a centralised IT system which was described as the control centre for the service. The centralised system was managed by a coordinator and has several functions, including: streamlining referrals, payments and reporting, coordinating the care pathway and providing expert advice to other clinicians including education and evaluation support.
Facilitation	One site through ongoing involvement in research trials, scheduled regular team meetings to workshop implementation issues associated with the research trials. The outcomes of these meetings were then applied more broadly to the exercise EBIs delivered at the site to optimise services.
Provide clinical supervision	One site had established a clinical supervision model where all healthcare providers were provided with fortnightly and then monthly sessions with a more senior colleague. This model provided clinical and non-clinical support for the workforce.
Provide local technical assistance	At one site a dedicated role existed that supported EBI delivery staff with operational issues (i.e., reporting issues, how to use the IT system and processing payments and guidance on clinical issues). This was an ad hoc, informal system of support.
Support clinicians	
Create new clinical teams	Two sites had created multi-disciplinary teams that provided a wrap-around service for patients. Members of the multi-disciplinary team were upskilled in their colleague's professional expertise.
Remind clinicians	One site had established a reminder system for the exercise EBI. This included: stickers placed on medical files prompting referral to exercise and adding the COSA exercise guidelines to the footer of the organisation's letterhead. Two sites used informal reminder systems (i.e., arranging coffee catchups with referral sources and leaving flyers about the service in common areas).
Revise professional roles	One site had revised roles over time to grow and enhance the exercise services. It commenced with converting an allied health assistant role to an exercise physiology role. This position was then *ring-fenced* to avoid it being taken away through the growth/retraction of organisational budgets. The initial role has slowly been added to, with more hours and number of AEPs. The original AEP has progressed to a higher level in the organisation, increasing their responsibilities and decision-making capacity.
Train and educate stakeholders	
Conduct educational meetings	Two sites conducted multi-disciplinary team meetings where staff could provide colleagues with updates on discipline-specific initiatives, such as progress on exercise EBI.
Create a learning collaborative	At one site the health district established a learning collaborative for AEP staff working at different sites. Separately, a collaborative that included multiple different healthcare disciplines was also established to support shared learning.
Provide ongoing consultation	At one site a secondary consultation service operated that provided advice to other clinicians delivering cancer services. This service included medical, nursing and allied health services (including exercise).
Shadow other experts	NA
Work with educational institutions	One organisation created an educational coordinator role. This role worked with a local university to deliver post-graduate courses. The role also worked with other organisations to develop internal and external training opportunities that built general workforce capacity.
Conduct educational outreach visit	NA
Make training dynamic	NA
Use train the trainer strategies	NA
Use evaluative and iterative strategies	

Assess for readiness and identify barriers and facilitators	Prior to establishing the service one site spent 12 months planning, identifying potential barriers and engaging with stakeholders to improve the likelihood of implementation success.
Audit and provide feedback	At one site staff were required to undertake an annual quality improvement project of their choice. The AEP was conducting a project to monitor the current triage process for the exercise service. The aim of this project was to improve the *right referral at the right time*, with the results planned for feedback to the triaging workforce.
Conduct cyclic small tests of change	At one site home exercise resources were trialled with a small group of patients before implementing widely in the service.
Stage implementation and scale-up	Two sites built the exercise EBI services over time (i.e., adding extra sessions/times and delivering exercise for different cancer streams). As the exercise EBI is expanded, efforts are then directed towards 'locking' the change into the system.
Purposely re-examine the implementation	One site only set exercise timetables for a term at a time. At the end of each term they re-assessed attendance rates to ensure class days/times were suitable for participants.
Conduct a local needs assessment	NA
Develop a formal implementation blueprint	NA
Use financial strategies	
Alter incentives allowance structures	NA
Alter patient, consumer fees	NA
Develop disincentives	NA
Fund and contract for the clinical innovation	NA
Make billing easier	NA
Use capitated payments	NA
Other payment schemes	NA
AEP = Accredited Exercise Physiologists, COSA = Clinical Oncology Society Australia, EBI = Evidence-based Intervention, IT = Information Technology, NA = Not Applicable	

Supplementary file 5: Simplified implementation logic model for Case Site A, B and C

Case Site A				
CFIR construct	**Summary of construct extracted from framework matrix**	**Implementation strategy (ERIC)**	**Mechanism**	**Implementation outcomes**
Individual (E)	**Self-efficacy (healthcare providers have the confidence to discuss exercise)**	**Conduct education meetings (multi-disciplinary team meetings)** **Conduct ongoing training (access to professional development courses)**	**Knowledge acquisition**	**Acceptability (provider)**
Individual (B)	**Stage of change (some healthcare providers act to refer, others don't)**	**Facilitate relay of clinical data to providers (patient progress sent to referral source at regular intervals through the program)**	**Reinforces expected (positive) outcomes**	**Penetration (service level)**
Inner setting (B)	Culture (poor culture across the broader organisation)	Promote network weaving (create opportunities for staff to mix across professional boundaries)	Social interaction	Acceptability (provider)
Inner setting (E)	Implementation climate (within the small team the program is agile, which allows it to adapt and respond despite austerity)	Create new clinical teams (multi-disciplinary team)	Professional role identity and responsibilities	Acceptability (provider) ↓ Penetration (service system)
Inner setting (E)	***Learning climate (ongoing learning permeates the organisation)***	***Facilitation (protected time to workshop implementation issues)***	***Action planning***	***Fidelity (quality)*** **↓** ***Sustainability (evolution over time)***
Inner setting (E)	*Organisational incentives and rewards (awards contribute to the prestige of the program)*	*Increase demand (patients act to demonstrate support/need for exercise) + Involve executive boards (feed intervention results to executive)*	*Advocacy (optimism belief in positive outcome)*	*Penetration (sub-system)*
Inner setting (B)	*Relative priority (competing demands for providers and organisation)*	*Remind clinicians (multiple methods - (stickers on hard-copy files, presentations, referral forms/evidence summaries at point of referral, 'footers' of letters)* *Develop and distribute educational materials (manuals, how to refer)*	*Remembering and decision-making prompt at the time of decision*	*Penetration (service level)*
Inner setting (E)	**Networks and communications (personal relationships and trust create efficiencies in operations)**	**Promote network weaving (create opportunities for staff to mix across professional boundaries)**	**Social interactions and professional identity**	**Acceptability (provider)** **↓** **Penetration (service level)**
Inner setting (E)	***Access to knowledge and information (one-stop-shop in survivorship)***	***Create new clinical teams (multi-disciplinary team)***	***Simplify decision-making***	***Penetration (service level)***
Inner setting (B)	***Available resources (lack of time and funding)***	***Access new funding (grants, fundraising, philanthropic donations)***	***Conditions for building material resources to develop organisational capability***	***Sustainability (program components)***

Inner setting (B)	*Leadership engagement (leaders have low awareness of the service)*	*Champion (works across and up to executive advocating to assure resourcing for exercise)*	*Persuade to impact intention to act*	*Penetration (sub-system)* ↓ *Sustainability*
Intervention (E)	**Adaptability (adapt the program to suit patient needs and referrals adapted to suit provider demands)**	**Develop and implement tools for quality monitoring (exercise-specific tools to track health outcomes and compliance)** **Promote adaptability (offer different exercise and referral processes)**	**Skill acquisition to support mastery of skills**	**Acceptability (consumer/provider)** **↓** **Sustainability (health outcomes)**
Intervention (B)	Cost (no secure funding for the program)	Involve patients' consumers and family members (fundraising efforts) → Access new funding (funding comes from multiple sources)	Increase material resources	Sustainability (program components)
Outer setting (E)	Cosmopolitan (a well-connected organisation that builds capacity)	Develop resource sharing agreement (relationship with local exercise services) Develop academic partnership (formal relationship with a university to *test and trial* program expansions	Develop material resources to build capacity	Fidelity ↓ Sustainability (program components and evolution over time)
Outer setting (E)	**External policies and incentives (leverage COSA position statement and exercise embedded in organisation reporting required by the State)**	**Change record system (exercise added to the online electronic scheduler) → Involve executive boards (feed intervention results to executive)** **Use mass media (emails blasts sharing COSA statements)**	**Align exercise with established goals and organisational performance targets** **Influence intention to act**	**Penetration (sub-system)** **↓** **Sustainability (program component)** **Acceptability**
Outer setting (E)	**Patient need and resourcing (patient satisfaction/needs are central to how the EBI is developed/delivered)**	**Obtain and use patient, consumer and family feedback (patient-reported outcomes (including satisfaction) collected)**	**Action planning (ongoing improvement activity)**	**Sustainability (evolution over time)**
Process (E)	***Engaging (Champion (persistent, influential across levels of the organisation and builds patient activation))***	***Champion (works across and up to executive advocating to assure resourcing for exercise)*** ***Increase demand (patients act to demonstrate support/need for exercise)***	***Persuades to change intention to act*** ***Build optimism and belief/confidence in positive outcomes***	***Acceptability***
Process (E)	**Reflecting and evaluating (review data to change practice)**	**Develop and organise a quality monitoring system (tracking system for who is using the service) → Purposely re-examine implementation (program times set for a limited duration)**	**Action planning**	**Fidelity (dose/amount)** **↓** **Sustainability (evolution over time)**

Case Study B				
CFIR construct	**Summary of construct extracted from framework matrix**	**Implementation strategy (ERIC)**	**Mechanism**	**Implementation outcomes**
Individual (B)	Individual identification with the organisation (different commitment to the organisation impacts site success)	Develop educational materials (script for co-ordinator and structured framework)	Procedural/task consistency	Fidelity (quality)
Individual	**Stage of change (program underpinned by behaviour change theory) (E)** **(Healthcare providers act to refer, although this is not universal) (B)**	**Prepare patients to be active participants (patients supported to lead on their care)** **Facilitate relay of clinical data to providers (regular updates provided to referral source)**	**Perceived behavioural control** **Reinforce expected (positive) outcomes**	**Acceptability (patient)** **↓** **Fidelity (dose/amount)** **Penetration (service level)**
Individual (E)	**Self-efficacy (program builds confidence in patients to exercise)** **Healthcare staff have the confidence to discuss exercise and know where to refer**	**Intervene with patients and consumers to enhance uptake and adherence (multiple adherence strategies applied)** **Conduct education meetings (presentations about exercise and the service); Conduct ongoing training (staff undergo exercise and cancer training course)**	**Ease and mastery of tasks** **Knowledge (procedural)**	**Acceptability (patient)** **↓** **Fidelity (dose/amount)** **Acceptability (Provider)**
Inner setting (E)	***Learning climate (staff are supported with ongoing learning and service improvement)***	***Provide local technical assistance (weekly meeting to workshop implementation issues)***	***Action planning***	***Fidelity (quality)*** **↓** ***Sustainability (evolution over time)***
Inner setting	**Networks and communications (hierarchy makes communication challenging (B). However, relationships between staff are strong and supportive (E))**	**Promote network weaving (provide social opportunities so staff build relationships)**	**Social interactions and professional identity**	**Acceptability (provider)**
Inner setting (E)	***Access to knowledge and information (easy to access information because the service is established as a one-stop shop)***	***Use mass media (website)***	***Simplify decision-making***	***Penetration (service level)***
Inner setting (B)	***Available resources (lack of funding, but lean service model operates)***	***Access new funding (fundraising, donations)*** ***Create resource sharing agreement (special fitness centre rates and pro-bono expertise)***	***Builds material resources to develop organisational capabilities***	***Sustainability (program components)***
Inner setting (E)	*Leadership engagement (leadership are highly engaged to ensure the program is a success)*	*Build a coalition (diverse partners are brought on board and sell a consistent message)*	*Optimism and group identity*	*Sustainability (program components and evolution over time)*

Inner setting (E)	Structural characteristics (site selection was purposeful to ensure optimisation of service)	Change service sites (hub and spoke model)	Decrease environmental barriers	Acceptability
Intervention (E)	**Adaptability (program has the flexibility to offer different exercise opportunities and referral pathways)**	**Develop and implement tools for quality monitoring (initial assessment forms, exercise sheets)** **Promote adaptability (exercise tailored to individual needs; multiple referral pathways)**	**Skill acquisition to support mastery of skills**	**Acceptability (consumer/provider)** **↓** **Sustainability (health outcomes)**
Intervention (E)	Complexity (centralised administration/process hub)	Centralised technical assistance (centralised IT system established)	Streamline work tasks	Penetration (sub-system)
Intervention (B)	Cost (funding to keep costs low)	Start a dissemination organisation (a non-for-profit established)	Increase material resourcing	Sustainability (program components, evolution over time)
Intervention (E)	Design quality and packaging (a professional, consistent image that lends to credibility)	Use mass media (image built across different mediums)	Program identity	Acceptability
Outer setting (E)	**External policy and incentives (exercise and cancer is a policy priority of the State and a dedicated funding stream established by the State)**	**Develop academic partnership (program commenced through research trial and continues to support research)** **Change record-keeping system (purpose-built IT system captures data for reporting) → Involve executive boards (relay outcomes to policy-makers)**	**Conditions to build capacity** **Align exercise with established goals/performance targets**	**Fidelity (dose/amount and quality)** **Penetration (sub-system)** **↓** **Sustainability (program components)**
Outer setting (E)	**Patient need and resourcing (advisory groups established that include consumers to direct patient-centred care)**	**Use advisory boards and working groups (consumers' experiences embedded in governance structures)** **Obtain and use patient, consumer and family feedback (patient-reported outcomes collected before clinic and used to inform service)**	**Action planning to optimise service continually**	**Sustainability (evolution over time)**
Process (E)	Engaging (oncology team *give permission* and can persuade people to exercise)	Identify and prepare champion (influential *expert* able to transcend levels)	Persuade to impact intention to act	Acceptability
Process (E)	***Champion – (influential and respected as an expert in the field of exercise oncology)***	***Increase demand (patient activation)***	***Build optimism and belief/confidence in positive outcomes***	***Acceptability***
Process (E)	Planning (12 months of planning before launch)	Assess for readiness and identify barriers and facilitators (planning, engaging stakeholder)	Action planning	Acceptability ↓ Penetration (sub-system)

Process (E)	**Reflecting and evaluating (review clinical data collected through centralised IT system)**	**Develop and organise a quality monitoring system (consistent data collection and input into the IT system)**	**Action planning**	**Fidelity** **↓** **Sustainability (evolution over time)**

Case Site C				
CFIR construct	**Summary of construct extracted from framework matrix**	**Implementation strategy (ERIC)**	**Mechanism**	**Implementation outcomes**
Individual (B)	**Individual stage of change (for some providers discussing exercise and referral is part of their routine practice, however, they make decisions about *timing* (see *relative priority*)**	**Facilitate relay of clinical data (providers have access to patient progress through exercise)**	**Reinforces expected (positive) outcomes**	**Penetration (service level)**
Individual (E)	**Self-efficacy (some staff are confident to have conversations, whilst others do not view it as part of their role)**	**Provide ongoing training (education and training course that build from short courses through to graduate certificates)** **Conduct education meetings (multi-disciplinary team meetings)**	**Knowledge**	**Acceptability (provider)**
Inner setting	Compatibility (E) (Selected parts of the organisation have fit exercise within the workflow (i.e., ‘opt-out’ referral system, linked to fitness for surgery) (B) Where fit has not been achieved, exercise is incompatible with organisation prioritises (acute care).	Tailor strategies (ongoing change to referral processes to ensure the best fit)	Action planning	Penetration (service level)
Inner setting (E)	***Learning climate – (staff undertake ongoing learning, including annual quality improvement program)***	***Provide clinical supervision (mentoring relationship)*** ***Nb: the exercise services’ current quality improvement program was to audit and provide feedback on triage processes (see structural characteristics)***	***Action planning***	***Fidelity (quality)*** **↓** ***Sustainability (evolution over time)***
Inner setting (B)	*Relative priority (staff are busy and so make decisions about what is the most critical issue to address at the time. Exercise is not a priority for the organisation, which operates a traditional bio-medical model*	*Prepare patients and consumers to be active participants (empower patients to shift clinician behaviour)* *Obtain and use patient, consumer and family feedback (collect feedback on response to exercise program)*	*Increase self-confidence and perceived behavioural control*	*Acceptability (patient)* ↓ *Penetration (service level)*

Inner setting (B)	*Tension for change (perverse incentives inhibit service growth)*	*Revise professional role (ring-fence human resources when opportunities present to grow service)*	*Build material resources*	*Sustainability (program components)*
Inner setting (E)	***Access to knowledge and information (exercise contained within a program (design and packaging) makes it simpler to access information)***	***Create new clinical teams (exercise offered within a multi-disciplinary program)***	***Simplify decision making***	***Penetration (service level)***
Inner setting (E)	**Networks and communication (personal relationships enhance referral to exercise)**	**Promote network weaving (build relationships between workforce to then dovetailing appointments)**	**Social interactions and professional identity**	**Acceptability (provider)** **↓** **Penetration (service level)**
Inner setting (B)	***Available resources (differing resourcing levels impacts agile service delivery)***	***Develop resource-sharing agreement (formal and informal agreements in place to increase access to exercise)*** ***Access new funding (private donations, philanthropic and other sources)***	***Develop material resources to build the capacity of the program to meet the demand***	***Sustainability (program components)***
Inner setting (B)	Structural characteristics (exercise in physiotherapy department) (Insufficient space and equipment in gym and poor location)	Audit and feedback (audit triage process to improve appropriate referral of services) Change service sites (move to a bigger site)	Reinforces desired behaviour Environmental interactions	Penetration (sub-system) Acceptability
Intervention (E)	**Adaptability (program adapted to suit patient preferences and referral sources)**	**Develop and implement tools for quality monitoring (templates to guide assessments and delivery)** **Promote adaptability (different exercise EBIs to accommodate patient preference and multiple referral options for the workforce)**	**Skill acquisition to support mastery of skills**	**Acceptability (consumer/provider)** **↓** **Sustainability (health outcomes*)***
Intervention (E)	Complexity (simplify referral processes)	Change record system (introduction of electronic medical records)	Ease, suitability and convenience (for providers)	Penetration (service system)
Intervention (E)	Evidence strength and quality (the accumulating evidence-based builds support for exercise)	Develop academic partnerships (run pragmatic research trials within routine care and work with the academic sector to develop education opportunities)	Skill acquisition	Fidelity (quality of care)
Intervention (E)	Relative advantage (exercise is beneficial for side-effects of cancer treatment, and it is the most effective mechanism to get people fit for surgery)	Develop educational materials (resources include exercise indications, exercise for fatigue and referral trial) NB – unclear where this information is disseminated	Establishes positive beliefs about anticipated outcomes	Acceptability (provider) ↓ Penetration (service level)

Outer setting (E)	**External policy and incentives – (COSA position statement used to legitimise exercise)** **(Exercise EBI aligned to State cancer plan and organisational reporting required by the State)**	**Inform local opinion leaders (a respected expert who can transcend organisational hierarchy)** ***Change record system (capture data)*** **↓** **Involve executive boards (bi-annual reporting)**	**Influence/shift intention to act** **Align exercise EBI with established goals/targets**	**Acceptability** **Penetration (sub-system)** **↓** **Sustainability (program components)**
Outer setting (E)	**Patient need and resourcing (advisory groups operate to drive consumer-directed care and satisfaction with exercise EBI is enhanced by tailoring to patient needs)**	**Obtain and use patient, consumer and family feedback** **Use advisory boards and workgroups (formal groups that have a seat in strategic decision-making)**	**Action planning and engaging in ongoing improvement cycles**	**Sustainability (evolution over time)**
Process	***Champion (lack of exercise champion is viewed as a barrier to 1:1 program (B). However, in other areas (youth), a champion has supported successful implementation (E)***	***Increase demand (use clinical data and advisory groups to demonstrate demand for service)***	***Persuade and build optimism***	***Acceptability***
Process (E)	**Reflecting and evaluating (use data to inform resourcing needs)**	**Implement a quality monitoring system (system to capture activity, outcome and referrals)** **NB: the outcomes of this work are documented in a record system and fed through executive boards)**	**Action planning**	**Fidelity (dose and amount)** **↓** **Sustainability (evolution over time)**

CFIR = Consolidated Framework for Implementation Research, COSA = Clinical Oncology Society Australia, EBI = Evidence-based intervention, ERIC = Expert Recommendations for Implementing Change, IT = Information Technology, **Bold** = common pathways across sites, *Italics* = Determinant is a sibling construct of another determinant in the CFIR