Efficacy and acceptability of physical activity integrated within substance use treatment for young people

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Abstract

Physical activity (PA) intervention has potential as an intervention approach for young people with problematic substance use. Currently, physical activity is not routinely integrated into substance use treatment in most countries, including Australia.

This thesis aims to investigate the potential integration of physical activity interventions into substance use treatment practice for young Australians. The three phases of the research examined the efficacy of PA interventions, explored young people's perspectives of PA and made recommendations for research and practice. The Consolidated Framework for Implementation Research (CFIR) and COM-B model of behaviour are used to guide and integrate the research.

Phase 1 investigates current research evidence on the effect of physical activity interventions for substance use in young people aged 12-25 years and explores behaviour change techniques that are applied as part of interventions by conducting a rigorous review and meta-analysis. The impact of the underreporting of implementation characteristics as part of the identified interventions is critically discussed.

Phase 2 explores correlates of treatment acceptability of PA interventions in young people (n=145) with problematic alcohol, tobacco or illicit substance use and their perspectives (n=4) on integrating PA interventions into treatment practice using a mixed-methods approach, including a quantitative research survey, a qualitative focus group and an integrated discussion.

Phase 3 combines findings from Phases 1 and 2 to provide recommendations for research and practice regarding integrating PA interventions into treatment practice for young people with problematic substance use.

Quantitative findings demonstrated the potential of different formats of PA interventions to reduce problematic substance use in young people; however, as the existing interventions vary widely in methodology, intervention design and the targeted substances, the evidence could not be synthesised meaningfully. While acceptability of PA interventions was high overall among participating young Australians with problematic substance use (aged 16-25 years), higher reported acceptability was associated with better mental health, lower perception of barriers to PA and higher PA participation. Quantitative findings further indicated that some young people report better mental health and may therefore be more "capable" to participate in PA interventions at this point, while others experience more

severe mental health concerns and may thus benefit from focussing on improving their mental health first and potentially only engage in achievable PA tasks (e.g., increasing active transportation). rather participating in a comprehensive intervention.

Qualitative exploration of the PA barriers experienced by young people revealed access/availability, logistical, and social barriers. Young people recommended tailored and preference-based PA interventions, engagement aids, clear directions and informative education on PA and substance use. Integrating these findings into a behavioural framework may support clinicians in identifying areas of priority when it comes to PA interventions.

To conclude, PA interventions are perceived as acceptable within the treatment of substance use among the young Australians who participated in this program of research. They may offer additive benefits if integrated with existing treatments. However, more research to establish efficacy of PA interventions for substance use treatment is required, including the investigation of different types of substance use. Recommendations for practice are provided, including an assessment of young people's capability to participate in such interventions and the identification of priority points of intervention, to improve young people's capability, opportunity and motivation for PA. Factors that might influence the translation of PA interventions into practice and policy are identified based on the preferences of young people involved in this study, highlighting the importance of including young people as critical stakeholders in intervention design and delivery to develop or further refine evidence-based interventions.

Keywords: Substance use, young people, young adults, physical activity, intervention

Declaration of Authenticity

I, Lisa [Lee] Klamert, declare that the PhD thesis entitled "Physical Activity Within Young People's Treatment for Substance Use: Integrating the Evidence and Young People's Perspectives" is no more than 80,000 words in length, including quotes and exclusive of tables, figures, appendices, bibliography, references, and footnotes.

This thesis contains no material submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my work.

I have conducted my research in alignment with the Australian Code for the Responsible Conduct of Research and Victoria University's Higher Degree by Research Policy and Procedures.

Ethics Declaration

All research procedures reported in the thesis were approved by the Victoria University Human Research Ethics Committee (VUHREC), approval number HRE22-039.

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Signature Date

Publications and Conferences

Chapter no.	Publication title	Publication status	Publication details
3.3.	Physical activity interventions for young people with increased risk of problematic substance use: A systematic review including different intervention formats	Published	(Klamert, Bedi, et al., 2023)
3.4	Behaviour change techniques in physical activity-focused interventions for young people at risk of problematic substance use: A systematic review and meta-analysis	Published	(Klamert, Craike, et al., 2023)
3.5	Underreporting of implementation strategies and barriers in physical activity interventions for young people at risk of problematic substance use: A brief report	Published	(Klamert et al., 2024)

Declaration by: Lisa Klamert **Signature:** **Date:** 12/03/2024

Modified parts of chapters 3 and 4 have been presented at the following conferences:

Klamert, L., Craike, M., Bedi, G., Kidd, S., & Parker, A. (2023). *Integrating physical activity in young people's substance use treatment: Shared intervention design.* Paper presented at the National Equally Well Symposium 2023, Sydney, Australia.

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Klamert, L., Bedi, G., Craike, M., Kidd, S., & Parker, A. (2023). *Tailored physical activity in substance use treatment for young people: Strengthening research collaborations with young people.* Paper presented at the Australasian Professional Society on Alcohol and Other Drugs 2023 Conference, Adelaide, Australia.

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List of Abbreviations

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
ACIC	Australian Criminal Intelligence Commission
ADHD	Attention Deficit Hyperactivity Disorder
ALRC	Australian Law Reform Commission
AOD	Alcohol and Other Drugs
APA	American Psychological Association
BCT	Behaviour change techniques
DSM	Diagnostic and Statistical Manual of Mental Disorders
ICD	International Statistical Classification of Diseases and Related Health Problems
PA	Physical activity
PYD	Positive youth development
SEIFA	Socio-Economic Indexes for Areas, Australia
SU	Substance use
UNDESA	United Nations Department of Economic and Social Affairs
UNODC	United Nations Office on Drugs and Crime
WHO	World Health Organization

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1 Introduction

This thesis explores the existing evidence and young people's insights and preferences regarding the integration of physical activity (PA) into substance use (SU) treatment for young people. The three-phased project is described in the form of a traditional thesis (i.e., a written piece of scholarly work) with publications resulting from this thesis included where relevant.

1.1 Chapter Introduction

Chapter 1 provides an overview of the topic and outlines the different phases of the research project. The chapter defines relevant terms that are being used throughout the thesis, such as physical activity, mental health, and substance use. Further, the development of the research question is described, including the context and background in which it originated. Finally, Chapter 1 explains the research aims and specific objectives the project is based upon and concludes with a brief methodology and chapter overview.

1.2 Explanation of Terms

1.2.1 Mental health and illness

The use of the term "*mental illness"* in this thesis is based on the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) by the American Psychiatric Association (APA) and refers to all diagnosable mental disorders (APA, 2022). Mental disorders involve disruptions in emotion, thinking or behaviour as a consequence or result of dysfunctional psychological, biological and developmental processes. The definition, therefore, recognises multiple aspects contributing to the development of mental disorders. Mental disorder is further associated with significant distress for the individual as well as impaired functioning in key life areas such as social relationships, education and employment (APA, 2022). Other terms used within this thesis which refer to decreases in an individual's mental health, namely *mental disorder*, *mental ill-health*, *mental health issues* or *mental health concerns*, are used synonymously, with no differentiation in the extent or severity of the presenting condition between the different terms.

1.2.2 Substance use

The term "*substance use*" (SU) refers to any consumption of substances including tobacco, alcohol, cannabis and illicit substances, irrespective of the extent of use or implications of the use. Other terms relating to substance use found within the existing literature, namely *substance consumption*, are used synonymously in this thesis.

"Problematic substance use in young people", a phrase used in the quantitative and qualitative research described in Chapters 3 and 4, refers to young people at moderate or high risk of experiencing health or other problems due to their substance use. In the studies included in this thesis, this was assessed with the Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) developed by the World Health Organization (WHO; WHO, 2010a). The phrasing aligns with the language used in the DSM-5, which describes substance use occurring on a continuum ranging from mild to moderate to severe (for detailed DSM assessment criteria see APA, 2013). The terminology has been adapted to suit the population of young people and minimise verbal pathologisation of individuals, particularly research participants (Frances, 2009). Instead of using the DSM diagnoses "moderate substance use disorder" or "severe substance use disorder" to describe participating young people, young people are described to be at "moderate risk" (of experiencing health or other problems because of their substance use) or "severe risk". By doing so, it is acknowledged that young people indeed often display risky substance use behaviours. However, it minimises the verbal stigmatisation in this thesis when referring to those young people (for more information on stigma see Ruesch, Angermeyer, & Corrigan, 2005). Additionally, some argue that "substance use disorder" better describes the behaviour of dependent adult users rather than young people who have more recent exposure to and use of substances (Stockings et al., 2016).

Notably, while moderate risk (i.e., moderate scores) as defined in this study likely indicates harmful substance use or moderate substance use disorder (according to the DSM-5), and high risk (i.e., high scores) likely indicates substance dependence or severe substance use disorder (WHO, 2010a), no actual data on whether participants met criteria for substance use disorder were obtained as part of this study.

1.2.3 Physical activity

The term "physical activity" (PA), as used in this thesis, refers to any kind of bodily movement requiring energy expenditure irrespective of intensity of movement or duration of participation. It thus includes different activities such as exercise, active transportation, yoga, walking and others. The use of the term aligns with the definition of physical activity provided by the WHO and is being used as an umbrella term and interchangeable with the terms "*being active*", "*exercise*", and "*fitness training*".

Physical activity, as defined by the WHO, is any *bodily movement produced by skeletal muscles that requires energy expenditure* (Casperson, Powell, & Chstenson, 1985; WHO, 2018) and can be divided into moderate-intensity physical activity and vigorous-intensity physical activity according to the relative required effort to conduct the respective activity and the resulting increase in an individual's heart rate. The term 'relative' refers to individual differences according to a person's fitness level; for instance, dancing may be considered as moderate physical activity for an athlete but as vigorous physical activity for an elderly person. Participation in physical activity is influenced by several determinants, such as education, self-motivation, behavioural skills, reinforcement, outcome expectations, knowledge of and beliefs about activity and health, which interact with environmental factors and personality traits to determine physical activity participation (Dishman, Sallis, & Orenstein, 1985). Physical activity can be further conducted in various ways and settings, for example, in a focused, structured and repetitive way to achieve a specific goal, such as increasing fitness (also called "exercise") or as part of daily necessities, such as walking to the train station on the way to work (Casperson et al., 1985).

As with exercise, the concept of physical fitness overlaps with physical activity. Physical fitness increases in direct relation and proportionally to levels of engagement in physical activity, as well as increasing the ability to perform physical activity by reducing the energy expenditure needed to achieve it.

1.2.4 Young people

The definitions of youth, adolescence and young adulthood vary greatly worldwide and often depend on the socio-cultural background or the context (e.g. legal, developmental, biological context) in which they are used. In many cases, the age spans of adolescence and young adulthood are merged under the common term 'youth'; however, in other cases, all three terms find themselves associated with different definitions.

The United Nations (UN), an intergovernmental non-profit organisation, defines "youth" and the interchangeable term "young people" as a population between the ages of 15-24 years, a developmental phase extending from the end of compulsory education and to a person's first employment. According to the United Nations' statistical estimate, young people account for around 16% of the current world population, estimated at about 1.2 billion. This number is expected to rise by another 0.1 billion by 2030 (United Nations, 2018; United Nations Department of Economic and Social Affairs [UNDESA], 2013).

A similar definition is proposed by the WHO, which adapts the original United Nations' definition of youth but adds two additional complementary definitions: "*adolescence*", referring to the population's fraction between the ages 10-19 years, as well as '*young people'* referring to the group of 10-24-year-olds (UNDESA, 2013). By doing so, the WHO recognises the distinct developmental needs and health-related matters during adolescence, as well as cerebral, physical, and biological changes, which are often unique to this phase and do not extend to early adulthood (WHO, 2014).

Another important factor relating to the definition of youth and young people is the cultural context, background and beliefs, with adolescents being old enough to marry in some countries but not old enough to leave school in others (Sawyer, Azzopardi, Wickremarathne, & Patton, 2018, p. 3). While acknowledging other definitions of *youth*, *young people*, *early adulthood* and *adolescence*, this thesis focuses on the Western comprehension of terminology, as the project is placed within an Australian context.

1.2.4.1 Definition of young people in this study

The group of young people investigated in this research project, which records an high prevalence of comorbid problematic substance use and mental health concerns (McGorry, Purcell, Hickie, & Jorm, 2007; United Nations Office on Drugs and Crime [UNODC], United Nations Office on Drugs and Crime, 2020), was overall 12-25 years old, with different age groups contributing to different phases of the research project. The age group was chosen to align with the definition of young people applied by headspace, the Australian national youth mental health organisation, which provides mental health support to the described population (Rickwood et al., 2019). In Phase 1, studies investigating the age range of 12-25 years were considered. Phase 2, in turn, focussed on young people aged 16-25 years, including mature minors, and excluding minors requiring parental consent. As the sample

extended from 16 to 25 years of age, it comprised individuals identified as adolescents and emerging adults (for details on emerging adults see Jeffrey Jensen Arnett, 2000).

1.3 Background to the Study

Australian data indicated an annual illicit substance use prevalence of 35% among young people aged 18-24 years (49% lifetime prevalence) in 2022-2023, with cannabis (25.5%) and cocaine (11.3%) more frequently used by this age group, while 14-17-year-olds used cannabis (9.7%) and inhalants (2.2%). Young people aged 18-24 years further reported high rates (42%) of harmful or dangerous drinking since 2019 (Australian Institute of Health and Welfare [AIHW], 2024). Despite an overall falling trend in substance use rates among 14-17 year olds, as indicated by the latest National Drug Strategy Household Survey, several new substance use trends have emerged in recent years (AIHW, 2024). For instance, e-cigarette use (or "vaping") has quintupled (9.7%) in 14-17-year-olds and quadrupled (21%) in 18-24-year-olds since 2019 (AIHW, 2024). Substance use can lead to significant impairments in key life areas during adolescence and young adulthood (Degenhardt, Stockings, Patton, Hall, & Lynskey, 2016; Hall et al., 2016; McGorry et al., 2007), and early onset of problematic substance use poses a substantial risk for the development of substance use disorder during adulthood (Volkow, Baler, Compton, & Weiss, 2014); thus, intervention during this period may limit negative long-term consequences in this population.

Historically, problematic substance use in young people has predominantly been treated using adult treatment models. However, several new evidence-based (inpatient and outpatient) treatment models specifically designed for a younger population have emerged in the past few years, which have generally demonstrated superiority to 'no treatment' conditions or regular adult treatment models (Winters et al., 2018). These evidence-based programs include family-based interventions, pharmacological treatments, motivational enhancement therapy (MET), brief interventions, cognitive behavioural therapy (CBT), treatment community (CT) and 12-step programs (Austin, Macgowan, & Wagner, 2016; Hammond, 2016; Hogue, Henderson, Becker, & Knight, 2018; Winters et al., 2018).

1.3.1 Early intervention in at-risk populations

Notably, early intervention approaches in young people comprise an understudied area of research. These approaches aim to intervene in early stages of substance use, for instance, when substance use has commenced or when young people display a risky use pattern and

are thus delivered before the substance use and associated harms increase (Stockings et al., 2016). Early intervention approaches further target so-called 'at-risk' populations with increased risk factors for problematic substance use, including young people living with a mental disorder (e.g., psychosis) or parental substance use, young people of low-socioeconomic position or identifying as a racial minority (e.g., Indigenous populations) (Degenhardt et al., 2016). Currently, several factors impede the implementation of early interventions for young people, namely the limited evidence on the effectiveness of early intervention approaches for substance use reduction in young people (Stockings et al., 2016) and the stigma often associated with vulnerable populations (Sussman & Sinclair, 2022). Physical activity may be an appropriate early intervention approach as it does not require young people to perceive their substance use as problematic and may engage young people in alternative ways to existing interventions (Klamert, Bedi, et al., 2023).

1.3.2 Physical activity interventions for substance use reduction

Recent research has highlighted the potential of physical activity to reduce problematic substance use and promote well-being in young people (Lynch, Peterson, Sanchez, Abel, & Smith, 2013; Parker et al., 2016; Simonton, Young, & Johnson, 2018; Smith & Lynch, 2012), however, the diversity in applied methodological approaches contributes to a lack of clarity regarding the efficacy of different intervention formats for different substance types. Further, physical activity has not been studied as an early intervention approach (see *1.3.1 Early intervention in at-risk populations*), and many existing PA intervention challenges, such as limited motivation to be physically active, are yet to be overcome (Muller & Clausen, 2015; J. Weinstock, Farney, Elrod, Henderson, & Weiss, 2017). Overall, physical activity interventions for substance use reduction in youth have not been investigated sufficiently to answer several critical questions concerning the effectiveness in real-life health care settings (Linke & Ussher, 2015), namely if interventions which have shown a beneficial effect for one substance type (e.g., sedatives) are also beneficial for other substance types (e.g., stimulants). While previous research has assessed the acceptability of PA interventions in individuals with severe mental illness (Lederman et al., 2017), existing literature has not yet examined the acceptability of these interventions in young people with problematic substance use. These gaps in research and knowledge impede the integration of physical activity interventions into substance use treatment practice.

1.4 Development of the Research Question

A preliminary review of the evidence revealed several gaps within the existing literature, which both fuelled and served as the basis for the research project:

Several seminal publications indicate a potential effect of physical activity interventions for substance use reduction in adults, namely systematic reviews conducted by Linke and Ussher (2015) and Zschucke, Heinz, and Strohle (2012). Another systematic review investigating the effect of physical activity on problematic substance use in young people indicated its potential as an intervention for substance use (Simonton et al., 2018), however limitations, including the absence of several critical review steps (Shea et al., 2017) and the predominant location of studies in educational rather than clinical settings limits the applicability of findings to practice change.

Existing research demonstrates a decline in physical activity and sports participation among young people (Allison, Adlaf, Dwyer, Lysy, & Irving, 2007; Hyde, Maher, & Elavsky, 2013), which overlaps with the peak age of onset of many mental disorders. The decline of PA during adolescence seems to be additionally increased by using certain substances (Ashdown-Franks et al., 2019). Nevertheless, treatment as usual or early intervention for problematic substance use does not integrate or target physical activity participation in young people (Simonton et al., 2018).

Other gaps in knowledge, as identified in the existing literature, included underlying behavioural mechanisms and treatment acceptability. While some studies described "overarching behavioural patterns" (Linke & Ussher, 2015, p. 9) in relation to the effect of PA interventions on substance use overall, only limited studies applied a framework of behaviour change theory to explain the described effect (Linke & Ussher, 2015; Smith & Lynch, 2012). Further, few studies have addressed existing treatment challenges in young people (Muller & Clausen, 2015; J. Weinstock et al., 2017), e.g., high ambivalence. To the author's knowledge, no research has examined the treatment acceptability of PA interventions in young people.

Assessing acceptability in intervention recipients is essential to the development and successful implementation of new healthcare interventions and may improve adherence and clinical outcomes in clients (Sekhon, Cartwright, & Francis, 2017). Further, the participation and integration of perspectives of intervention recipients (i.e., young people) in intervention development is foundational to the contemporary understanding of evidence-based practice

(Rubin, 2008; Sekhon, Cartwright, & Francis, 2018). Meaningful inclusion of young people may further give young people agency within relevant discussions (B. Checkoway, 2011; B. N. Checkoway & Gutierrez, 2006). Exclusion of young people from their own treatment decisions in turn may lead to negative experiences by disempowering young people, depriving them of their right to autonomy and neglecting their voice (Akther et al., 2019). While Australian legislation recognises young people's rights to contribute to decisions concerning their treatment, many current health services fail to integrate young people's preferences and perspectives (Human Rights and Equal Opportunity Commission, 1992; Mental Health Coordinating Council, 2015; Victorian State Government, 2014). In exploring new interventions such as integrating physical activity as part of substance use treatment practice for young people, it is thus essential to include young people's perspectives and assess acceptability of the intervention in the target group.

Based on the identified gaps, the following research question was formulated to guide the research studies reported in this thesis:

How efficacious and acceptable are physical activity interventions as part of substance use treatment for young people?

1.5 Research Aims and Objectives

Based on the overarching research question, the following aims were derived:

(a) Explore the effect of physical activity interventions for the treatment of problematic substance use in young people who are 'at-risk'.
(b) Assess young people's acceptability, barriers, preferences and service needs regarding PA interventions.
(c) Provide recommendations for clinical practice and future research regarding the integration of PA interventions into substance use treatment practice.

The individual aims were converted into several sub-questions, which in turn were addressed within separate phases of research and thus jointly built the doctoral research project:

(1) What are the effects of physical activity interventions on problematic substance use in adolescents and young adults, and can effective behaviour change techniques and mechanisms be identified (RQ1)?

(2) What factors contribute to the acceptability of physical activity interventions in young people with problematic substance use, and what are young people's preferences, insights and barriers regarding the integration of PA interventions into substance use treatment practice (RQ2)?
(3) What are the recommendations for clinical practice and future research directions (based on RQ1 and RQ2) regarding the integration of PA intervention into substance use treatment practice for young people?

In addition to the overarching research questions and the listed aims, several specific objectives were developed:

(a) Conduct a systematic review to appraise and synthesise the existing evidence on the effect of physical activity interventions for young people at risk for problematic substance use.
(b) Investigate the identified evidence in the context of behaviour change theory and extract reported behaviour change techniques (BCT).
(c) Quantitatively explore the correlates of acceptability of PA interventions in young people using a research survey.
(d) Qualitatively explore young people's perspectives on the integration of PA interventions into existing substance use treatment, including their preferences, insights and experienced barriers, as part of a focus group.
(e) Synthesise knowledge gained from objectives a)-d) and critically discuss the findings in the context of problematic substance use in young people.
(f) Provide recommendations for clinical practice and future research based on a)-e).

1.6 Methodology Overview

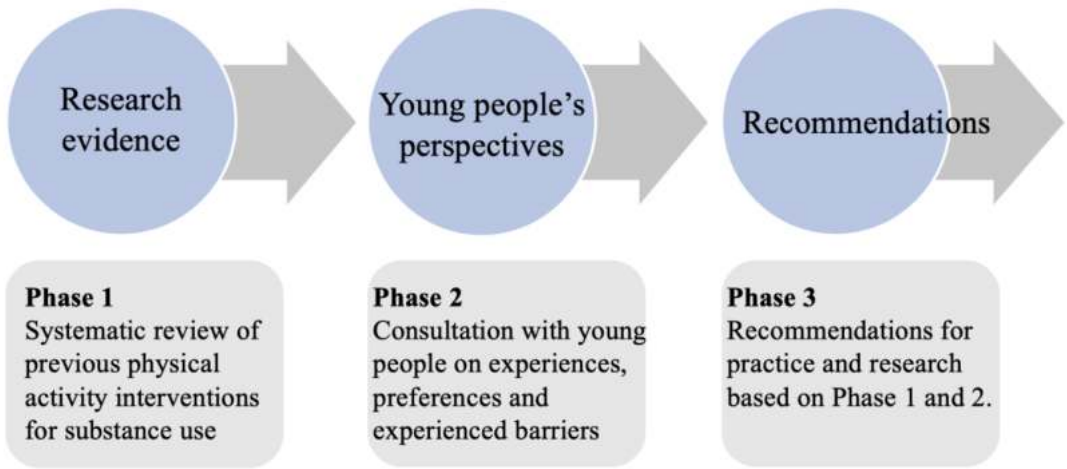
The project was guided by a deductive, mixed methods approach and was embedded within an interpretive research philosophy. Within this research philosophy, it is assumed that a subject's reality is created within the topic itself and can, as such, only be subjective. Consequently, research phenomena are seen as inseparable and embedded within the relevant value systems and contexts in which they occur (Alharahsheh & Pius, 2020). The strength of the applied mixed methods approach, which is considered a gold standard within clinical research, is that quantitative and qualitative methods complement and compensate for each other's weaknesses and provide meaningful context to participants' experiences

within a measurement framework (Regnault, Willgoss, Barbic, & International Society for Quality of Life Research Mixed Methods Special Interest Group, 2018).

The research project was designed in three phases in line with the research questions in *1.5 Research aims and objectives,* with each phase contributing new knowledge and building upon the previous phase (see Figure 1). Phase 1 investigated the existing evidence by conducting a systematic review and meta-analysis. Phase 2 explored the acceptability of physical activity interventions in young people with problematic substance use, as well as young people's perspectives, preferences, and experienced barriers regarding the integration of physical activity interventions into substance use treatment practice, using a mixed methods approach. Phase 3 synthesised previous findings to provide recommendations for clinical practice and future research.

Figure 1

Phases of the research project



1.6.1 Phase 1 - Existing evidence: Systematic review and meta-analysis

What is the effect of physical activity interventions on problematic substance use and associated outcomes in adolescents and young adults, and can effective behaviour change techniques and mechanisms be identified in existing literature (RQ1)?

In Phase 1, the first research (sub-) question was investigated by conducting a systematic review and quantitative meta-analysis. The review aimed to establish the evidence base for the subsequent research by examining the effect of different physical activity intervention formats, including comprehensive long-term interventions and short-term interventions, on

substance use in young people aged 12-25 years. Phase 1 further examined the effect of behaviour change techniques applied within the included interventions and critically discussed implementation characteristics that were extracted as part of the review process. Phase 1 was divided into three separate peer-reviewed publications.

Publication 1 reports on the effect of PA interventions on young people with problematic substance use in general, as well as comparing different intervention formats. The publication further discusses the potential of varying intervention formats to be integrated into routine substance use care for young people.

Publication 2 examines the effect of behaviour change techniques applied as part of the included physical activity interventions on substance use in young people and synthesises the effect using meta-analysis. Reported behaviour change strategies were extracted according to the "Coventry, Aberdeen & London – Refined" (CALO-RE) taxonomy of behaviour change strategies (Michie, Ashford, et al., 2011).

Publication 3 critically outlines the limited reporting of implementation characteristics as part of the investigated studies, including implementation strategies and barriers, acceptance of the interventions among non-research personnel and intervention fidelity. The publication further discusses the importance of reporting implementation characteristics as part of intervention studies to streamline the translation of effective interventions into practice and provides recommendations for future research.

1.6.2 Phase 2 - Young people's perspectives: A mixed methods study

What factors contribute to the acceptability of physical activity interventions in young people with problematic substance use, and what are young people's preferences, insights and barriers regarding the integration of PA interventions into substance use treatment practice (RQ2)?

In Phase 2, correlates of the acceptability of physical activity interventions for young people with problematic substance use were explored using a mixed methods approach following a sequential explanatory design. Further, young people's perspectives on the integration of PA interventions into substance use treatment practice were explored. Young people with problematic substance use were invited to participate in a quantitative research survey inquiring about their substance use, physical activity participation, experienced barriers and benefits to physical activity, and acceptability of PA interventions. Next, a qualitative focus

group was conducted, which explored the perspectives of young people regarding the integration of PA interventions into substance use treatment practice. The obtained quantitative findings (i.e., research survey) and qualitative findings (i.e., focus group) were integrated to facilitate an exploration of potential points of intervention and changes required for successful implementation of PA interventions for young people with problematic substance use. Phases 1 and 2 provided the evidence base for the clinical and research recommendations in Phase 3.

1.6.3 Phase 3 - Recommendations

Based on Phase 1 and 2, what are the recommendations for clinical practice and research regarding the integration of physical activity interventions into substance use treatment practice for young people (RQ3)?

The third and final research (sub)-question (Phase 3) aimed to draw together findings from the first two phases of this research project, critically discuss the evidence in light of previous research findings and the context of young people with problematic substance use in Australia and provide recommendations for research and practice.

1.6.4 Consolidated Framework for Implementation Research

The updated Consolidated Framework for Implementation Research (CFIR) was used as a guiding framework for the research project (https://cfirguide.org/). The CFIR was developed to better understand the contextual factors that influence the successful implementation of evidence-based interventions. Numerous interventions, which have been shown to be effective under controlled trial conditions, fail to be successfully implemented due to the limited understanding of the dynamic ("real-world") contexts that influence implementation. Consequently, the framework aims to explore barriers and facilitators to successful implementation to increase "implementation effectiveness". Additionally, the CFIR enables the strategic selection of implementation strategies based on these contextual factors (Damschroder, Reardon, Widerquist, & Lowery, 2022).

The framework draws upon a broad spectrum of constructs, theories and models, which are combined into one single, organising framework operating across five domains (intervention/innovation, outer setting, inner setting, individuals, implementation process). These five domains equally influence the implementation of interventions and interact with

each other (Figure 2). By providing a comprehensive and consistent organisational framework, the CFIR is adaptable and can be applied to a range of settings and needs such as theory development, systematic assessment of barriers and facilitators, generating context-specific models or developing and implementing innovative interventions. The CFIR has been tested in numerous contexts, including physical activity (Carlson et al., 2020; Lau, 2016; Rogers et al., 2019) and substance use research (Cannon et al., 2019; Damschroder & Hagedorn, 2011; Sorensen & Kosten, 2011).

1.6.4.1 CFIR and the research project

The Updated CFIR was chosen as an appropriate framework for the studies included in this thesis as it focuses on the implementation of interventions which have been shown to be efficacious within health research but have challenges in the translation into clinical practice. Similar to PA interventions, ineffective implementation of these interventions means that they are not consequently accessible to individuals who would otherwise benefit from their availability (Damschroder et al., 2009).

The research project explores several domains of the framework in Phase 1, including the "Innovation domain" (see Table 1). Additionally, the project investigates various implementation barriers and strategies in PA interventions as part of Phase 1, which are located on the framework domains "Outer setting", "Implementation process" and "Inner setting" (see *Chapter 3. Existing Evidence: Systematic Review and Meta-Analysis*).

The project further explores relevant factors regarding acceptability and young people's perspectives regarding the integration of physical activity interventions into substance use treatment practice in Phase 2. These perspectives give insights into the individuals domains of the framework (Characteristics subdomain), including constructs on need, capability, motivation, and opportunity of affected individuals (see *Chapter 4. Young People's Perspectives: A Mixed Methods Exploration*).

A framework of implementation science such as the CFIR is essential to intervention research as implementation questions need to be considered in the early stages of the research process (including efficacy and effectiveness research) to facilitate a streamlined translation of interventions into practice at a later point and ensure a timely availably of effective interventions to affected individuals (see chapter *3.5 Underreporting of Implementation Characteristics: Publication 3* for the interconnectedness of intervention research and implementation science).

Table 1

Domains and constructs of the updated CFIR (Damschroder et al., 2022)

Domain	Innovation	Outer setting	Inner setting	Implementation process	Individuals
Constructs	Innovation source Innovation evidence-base Innovation relative advantage Innovation adaptability Innovation trialability Innovation complexity Innovation design Innovation cost	Critical incidents Local attitudes Local conditions Partnerships & connections Policies & law Financing External pressure (Societal, market) Performance measurement	Structural characteristics (Physical infrastructure, information technology infrastructure, work infrastructure) Relational connections Communication Culture (Human equality-centeredness, recipient-centeredness, deliverer-centeredness, learning-centeredness) Tension for change Compatibility Relative priority Incentive systems Mission alignment Available resources (Funding, space, materials & equipment) Access to knowledge & information	Teaming Assessing needs (Innovation deliverers, innovation recipients) Assessing context Planning Tailoring strategies Engaging (Innovation deliverers, innovation recipients) Doing Reflecting & evaluating (Implementation, innovation) Adapting	Roles subdomain High-level leaders Mid-level leaders Opinion leaders Implementation facilitators Implementation leads Implementation team members Other implementation support Innovation deliverers Innovation recipients Characteristics subdomain Need Capability Opportunity Motivation

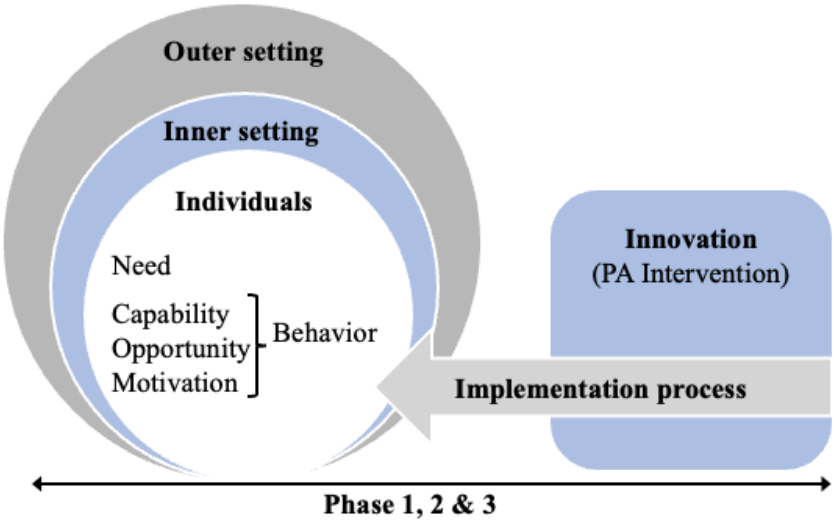
1.6.5 Capability- Opportunity- Motivation- Behaviour model of change

Phase 2 (Young People's Perspectives) and 3 (Discussion and Recommendations) were additionally guided by the *Capability- Opportunity- Motivation- Behaviour* (COM-B) model of behaviour change (Michie, Van Stralen, & West, 2011), which highlights three interacting conditions necessary to provoke volitional behaviour: capability (C), opportunity (O) and motivation (M). Capability refers to the knowledge, skills, and psychological/ physical capacities of an individual to engage in the target behaviour. Opportunity, in turn, is defined as the sum of factors outside of an individual's control that may enable behaviour. Motivation refers to any brain processes directing, fuelling or driving behaviour, such as goals, decision-making, analytical thinking and habitual processes (Michie, Van Stralen, et al., 2011). In this comprehensive, highly dynamic model, the three described components may influence and interact with each other to generate behaviour (B), which may again affect one or more of the three components through positive or negative feedback loops (Robert West & Michie, 2020b).

The COM-B model was chosen as a suitable theory to guide the project, as it investigates which components (capability, opportunity or motivation) need to change in order for an intervention to successfully prompt behaviour change (Robert West & Michie, 2020b). The theory thus ties in with experienced barriers to PA and PA interventions as investigated in Phase 2 (referring to opportunity, motivation and capability), as well as young people's preferences, some of which may provide insights into potential ways to overcome known treatment challenges (for challenges see chapter *1.3.2 Physical activity intervention for substance use reduction*). The COM-B model further allows integration with the CFIR, which highlights several constructs in line with the model as part of the 'Individuals' domain (see Figure 2). The model has been successfully applied to and trialled in various physical activity (Ellis, Pears, & Sutton, 2019; Flannery et al., 2018; Howlett, Schulz, Trivedi, Troop, & Chater, 2019; Spence et al., 2021) and substance use contexts (Gargaritano, Murphy, Auyeung, & Doyle, 2020; Kalema et al., 2017; Kwah, Fulton, & Brown, 2019) to analyse, explain and predict respective behaviour.

Figure 2

Domains of the updated CFIR (Damschroder et al., 2022) and integrated COM-B model (Michie, Van Stralen, et al., 2011)



1.7 Research Ethics

Phase 2 of the research project received approval from the Victoria University Human Research Ethics Committee (approval HRE22-039) and was conducted according to the NHMRC requirements for ethical research (NHMRC, 2023).

Several risk management strategies were used in Phase 2 to mitigate the risk of discomfort associated with the data collection on mental health and problematic substance use as part of the online survey and focus group. These included the provision of Australian and Melbourne support resources in the online survey and access to a mental health clinician during the focus group. For detailed information on recruitment processes (participant information and informed consent) and data collection and management processes, see Appendix B.1-Appendix B.5.

1.8 Significance of the Research

Australia currently reports the highest annual prevalence rate of cocaine use worldwide, high ecstasy and cannabis use, as well as a yearly illicit substance prevalence rate of about 16% (2019) among 14-19-year-olds (AIHW, 2020; UNODC, 2023). Further, cannabis and the stimulants ecstasy and crystal methamphetamine are among the most prevalent illicit substances used among young Australians (Australian Criminal Intelligence Commission [ACIC], 2017; Guerin & White, 2020; UNODC, 2019), with legal substances at equally concerning levels, particularly for e-cigarette use (see also chapter *2.2.3 Substance use in young people* for more details).

In 2021-2022, an estimated 38.7%% of young Australians aged 16-24 years and thus the highest proportion compared to any other age group, were affected by a mental disorder (12-month prevalence; Australian Bureau of Statistics [ABS], 2023b). Of these young people 7.8% reported being affected by substance use disorder (ABS, 2023b). In 2019, mental health was reported to be among the top four concerns of Australian youth (Carlisle et al., 2019). High numbers of mental health concerns and connected ineffective coping and problematic SU are associated with long-term impairments in behaviour, education, employment, relationships and well-being (WHO, 2019), as well as suicidal ideation. This is of particular concern as suicide is the leading cause of death among young Australians (ABS, 2023a; AIHW, 2021).

With significant emotional and behavioural problems in young Australians struggling with mental health and problematic SU, a focus on advancing existing treatments and translation of effective research evidence into practice should be a key focus to improve psychological and physical health, as well as reduce problematic substance use. By strategically placing this project within an implementation framework, the project aimed to create an evidence base for subsequent intervention development and delivery in the future.

Although numerous evidence-based treatments exist, several known treatment challenges, such as low motivation and ambivalence, interrupt young people's progress (J. Weinstock et al., 2017). Additionally, existing treatments commonly require young people to identify their substance use as problematic (Hofmann, 2012) and are often associated with social stigma regarding substance use (Hammarlund, Crapanzano, Luce, Mulligan, & Ward, 2018; Peretti-Watel, 2003), thus highlighting the need to explore less stigmatising treatments, which may also increase young people's motivation.

The new and emerging field of participatory research itself bears excellent potential for substance use interventions. By integrating young people's perspectives as part of intervention development, interventions may be more useful and accepted by young people. It may also provide young people with a sense of accomplishment and meaning (Sanders, 2002; Thabrew, Fleming, Hetrick, & Merry, 2018). The research reported here aimed to incorporate young people's voices as a first step towards participatory research.

1.8.1 Personal significance: Real-life clinical example

The research stemmed from the author's personal experiences working in an inpatient and outpatient service for young people with problematic substance use in Western Germany. These young people presented with several comorbid diagnoses in addition to substance use

disorder including attention deficit hyperactivity disorder (ADHD), depression, and/or conduct disorder. The patient group consisted of predominantly court-mandated young people aged 12-18 years, who tended to present with low intrinsic motivation, as well as challenges in adhering to treatment and, consequently, reported significant drop-out rates from treatment. Many of these young people were living in youth group homes or were homeless occasionally squatting in empty buildings or living on the streets. Within the inpatient service, young people expressed feelings of anger and disempowerment due to involuntary hospitalisations. In working through the young peoples' psychosocial histories, most reported a decline in sports participation that seemed to be related to the onset of, and increase in problematic substance use. In exploring this with young people during their treatment, many expressed an explicit preference for returning to a more active lifestyle. Despite these observations, physical activity engagement was not addressed or considered by treating clinicians at any point during standard treatment in the outpatient and inpatient services. Physical activity participation was further not addressed by any member of the clinician team, despite young people voicing their preferences in this regard. Without the capacity to explore why this was the case, it is difficult to know how this substance use service could address the problem of insufficient physical activity engagement in the young people receiving treatment at this service.

This example illustrates the practical background to the research, which was conducted to address several of the outlined challenges, including the lack of consideration of young people's preferences and the lack of integration of physical activity as part of standard treatment.

1.9 Chapter Outline of the Thesis

Chapter 1 of this thesis provides a general overview of the topic and outlines the different phases of the research project. The chapter began by defining relevant terms consistently used throughout the thesis, such as physical activity, mental health, and substance use. The chapter described the context and background of the research question and explained the aims, objectives, significance of the research project, and provided a methodical overview.

Chapter 2 provides a description of relevant background knowledge to this doctoral research project, including current physical activity recommendations for young people, substance use, mental health, and the burden of disease in young people in Australia. The chapter provides more detail on the theoretical framework upon which the research project is

based. Chapter 2 concludes by providing a theoretical framework for the project and discussing the importance of youth participation in the conducted research.

Chapter 3 (Phase 1) describes the existing evidence base on physical activity interventions for young people with problematic substance use in the form of three peer-reviewed publications. The publications highlight the diversity of existing PA interventions (Publication 1), investigate the use of behaviour change techniques as part of these interventions (Publication 2) and critically discuss the ramifications of underreporting of essential implementation characteristics as part of PA interventions (Publication 3). Chapters 1-3 lay a foundation for the in-depth investigation of young people's perspectives on physical activity interventions as part of substance use treatment.

Chapter 4 (Phase 2) explores young people's insights and preferences regarding the integration of physical activity interventions into substance use treatment practice using a mixed methods approach, i.e. a three-part approach integrating qualitative, quantitative and mixed methods results. First, the chapter reports on existing substance use, physical activity participation, mental health, physical activity barriers and treatment acceptability of physical activity interventions using data collected from a quantitative online survey. The chapter then describes qualitative insights from a focus group that explored young people's treatment preferences and concludes by integrating the quantitative and qualitative findings in a mixed methods discussion.

Chapter 5 (Phase 3) draws together the research background, existing evidence base, and reported insights from young people (as outlined in chapters 1-4) and reviews the practical implications of the conducted research and research outcomes. It further provides recommendations for practice and future research, as drawn from the research findings, and critically discusses the importance and ethical relevance of integrating young people into research and treatment delivery.

2 Literature Background

2.1 Chapter Introduction

Chapter 2 provides an in-depth description of the background and behavioural framework of the research project. The phenomena discussed in this chapter refer to the age group of young people (12-25 years). Further, the chapter elaborates on several distinct issues that commonly emerge and develop during adolescence and early adulthood and describes possible treatment options and consequences (in the case of treatment absence). These issues include mental ill-health, a decline in physical activity, high-risk behaviour, including substance use, as well as the distinct powerlessness and vulnerability that marks this period of development. By doing so, the chapter highlights the practical significance underlying the research project, as most of these issues can lead to long-term impairments in young people's lives. Chapter 2 concludes by highlighting the importance of including young people's perspectives in research and describing the theoretical framework that will be applied to the overall research project, the research questions, and the related phenomena.

2.2 Youth, Adolescence and Young Adulthood

2.2.1 Characteristics of adolescence and young adulthood

Adolescence commonly starts around the age of 13 for both girls and boys (including the first menarche and ejaculation), however, perspectives on when adolescence ends differ around the world (WHO, Sawyer et al., 2018; 2014). Typical characteristics associated with adolescence include neurodevelopmental, physical, psychological, emotional, and behavioural changes. According to Sawyer et al. (2018) another distinct characteristic of adolescence is simultaneous pattern of rapid biological growth and major role transitions. Adolescence is further described as the peak age of onset of many psychiatric problems (including the use of alcohol and other drugs [AOD]) (Blakemore, 2019), as well as juvenile delinquency (Murray, Hafetz Mirman, Carter, & Eisner, 2021).

Young or "emerging" adulthood, in turn, refers to the ages of 18-25 years, a prolonged transition period between adolescence and adulthood, characterised by a high frequency of changes in several significant life areas such as place of residence, employment and romantic/intimate relationships (Jeffrey Jensen Arnett, 2000; Jeffrey J. Arnett, Žukauskienė, &

Sugimura, 2014). While adolescence and young adulthood share common characteristics, namely great uncertainty, instability and frequent changes in significant life areas, a distinct recognition of emerging or young adulthood as a discrete life phase is important for the health system. Compared to adolescents, young adults are legally recognised as adults, can refuse treatment, and need their capacities, abilities (for instance, for informed decision-making) and independence to be recognised by the health system (Jeffrey J. Arnett et al., 2014).

Although adolescence is recognised as the peak age of onset for many psychiatric disorders, there is a high percentage of 12-month prevalence of mental disorders particularly within the age span of emerging adulthood (Jeffrey J. Arnett et al., 2014). In Australia, young people aged 20-24 years reported the highest rates of psychological distress, agitation, psychological fatigue and depression between 2017- 18 (ABS, 2018b) and continue to account for a significant part of overall AOD service use despite their equally high treatment disengagement (AIHW, 2018a, 2019).

2.2.1.1 Neurodevelopmental changes in adolescence

Adolescence is a period of rapid change. Apart from obvious physical changes, many young people also experience hormonal changes, behavioural, and emotional changes, partly caused by neurodevelopmental changes in the cerebral regions of the pre-frontal cortex and the nucleus accumbens. The nucleus accumbens, which contributes to sensation seeking and reward processes, has greater activity during adolescence compared to other age groups (Sisk & Gee, 2022). Neurodevelopmental changes during adolescence further provoke a hyper-responsivity to reward processes and a significant increase in sensation-seeking and risk-taking (Fryt, Smoleń, Czernecka, Szczygieł, & La Torre, 2021).

Many of these neurobiological and behavioural changes correspond to the substantial experimentation and exploration that occurs during this period, and also with high-risk behaviour such as delinquent behaviour, suicidal attempts, high-risk sexual behaviour, a lack of self-control and problematic substance use. Substance use, in turn, may also influence neurodevelopmental changes during this age phase (Thorpe, Hamidullah, Jenkins, & Khokhar, 2020).

2.2.2 Substance use in young people

As young people's substance use has been associated with numerous adverse outcomes, such as long-term impairments in significant life areas and high economic costs, recent research has

aimed to emphasise youth substance use as an increasing global health priority (Degenhardt et al., 2016). Young people are at particular risk of experiencing severe adverse health effects of problematic substance use due to their limited experiences with safely dosing the substances they are using and their increased vulnerability to substance dependence (Hall et al., 2016).

2.2.2.1 Substance use in young Australians

Young Australians have been identified as a priority population within the National Drug Strategy 2019-2026 due to their risk of experiencing disproportionate harm, including increased susceptibility to atypical brain development due to their substance use (Australian Department of Health, 2017).

While substance use has overall declined in young Australians since the start of the last century, substance use continues to be high in young people and recent changes in young people's substance use behaviour are cause for new concerns from a public health perspective, including the prevalence of substance use in vulnerable populations such as young people experiencing mental illness (AIHW, 2023b). Positive changes in recent years included an increase in the average age of substance initiation for several substances, including alcohol, tobacco and illicit substances, i.e., in Australia young people smoke their first cigarette, consume their first drink of alcohol and consume their first illicit substance at a later age than in previous years (AIHW, 2023b). However, illicit substance use remains highest among young people compared to any other age group, with particularly young people aged 18-24 being affected (AIHW, 2024). Recent years also showed a substantial increase in young female's illicit substance use, as assessed by the National Drug Strategy and Household Survey in 2022-23, which particularly showed in their cannabis and cocaine use (AIHW, 2024). Additionally, new drug trends have emerged in recent years, including the rise of e-cigarettes (from 19.1% to 26% per cent lifetime use in young people aged 18-24 years), the long-term health impacts of which are yet to be fully determined (AIHW, 2023b). Further, in 2019, 42% of young adults aged 18-24 years reported risky binge drinking behaviour (according to national alcohol risk guidelines) (AIHW, 2020, 2023a; 2023b). With alcohol and other drugs continuing to be among the leading causes of the burden of disease for many young people aged 15-24 years in Australia (AIHW, 2021), substance use in young people continues to be a concern from a public health perspective.

2.2.3 Mental health in young people

Similar to the timing of engagement in substance use, many psychiatric conditions emerge during adolescence. Sawyer et al. (2012) describe adolescence as the foundation of future health, a period in which several independent developments collide, interact and subsequently initiate a trajectory for adult health. Notably, these developments are significantly influenced by adverse childhood experiences (e.g., childhood maltreatment, exposure to violence) (Boullier & Blair, 2018; Gajos, Miller, Leban, & Cropsey, 2022). In particular, young people who have experienced four or more adverse childhood experiences are at significantly increased risk of developing mental illness including substance use disorder (Gajos et al., 2022).

With adolescence being described as a high-risk period regarding the onset of numerous psychological, behavioural, and physiological issues (Goodyer, Herbert, Tamplin, & Altham, 2018), it comes as no surprise that there is a high prevalence of comorbid substance use and psychiatric conditions during adolescence. Young people affected by problematic substance use commonly report significantly poorer health outcomes over their life course and are more likely to relapse following substance use treatment. For these reasons, it is essential to consider comprehensive treatment of problematic substance use while considering comorbid mental health concerns to improve prognoses for affected young people (Deas & Sherwood Brown, 2006).

2.2.4 Physical activity in young people

Another factor relevant to the development stage of adolescence and young adulthood is PA and/or sports participation. Both Australian (AIHW, 2018b) and international research reports a significant decline of physical activity during adolescence (Farooq et al., 2020; Sember, Jurak, Kovac, Duric, & Starc, 2020) and young adulthood (Corder et al., 2019), which overlaps with the peak age of onset of many psychiatric conditions (Solmi et al., 2022) and initiation of substance use and substance use problems.

In 2017-2018, only 11% of 15–17-year-old Australians (16% male, 5.3% female) were sufficiently active to gain or maintain health benefits, compared to 55% of 18–24-year-olds (59% male, 52% female), with males generally being more active than females. In line with physical activity recommendations for the age group of young people (WHO, 2010b), adolescents 15-17 years of age were sufficiently active if they completed at least 60 minutes of moderate-vigorous intensity PA per day and young adults aged 18-24 years when they completed at least 150 minutes of moderate to vigorous intensity activity per week. Activities

included sports, active transportation, and physical education in various contexts, including family, school or community. Notably, the large differences in rates of sufficiently active individuals between the age groups 15-17 and 18-24 years may be explained by the differing recommended activity levels between those two groups (AIHW, 2023c).

2.2.4.1 Physical activity and substance use

The decline of participation in PA during adolescence may be reinforced by the use of certain substances (Ashdown-Franks et al., 2019); however, the nature of this relationship remains ambiguous (Brellenthin & Lee, 2018). For instance, alcohol appears to have a positive correlation with sports participation (i.e. the higher the sports participation, the higher the alcohol use) among young people and young adults; tobacco and other substance use, on the other hand, seem to be negatively correlated with sports participation (i.e. the higher the sport participation, the lower the SU) (Brellenthin & Lee, 2018).

Despite the above-described inconsistency in findings regarding the specific association of physical activity and different substances, several intervention studies have demonstrated an overall significant positive effect of physical activity or exercise-based interventions integrated with regular treatment for substance use reduction (Leasure, Neighbors, Henderson, & Young, 2015; Linke & Ussher, 2015; Rosenbaum et al., 2016; Simonton et al., 2018). However, the number of PA interventions examined in randomised controlled trials for SU is limited (Simonton et al., 2018).

2.3 Physical Activity Interventions

The integration of physical activity with mental health and substance use treatments is increasingly considered due to its many benefits for health and well-being in all age groups (Mahindru, Patil, & Agrawal, 2023; Zhang & Liu, 2022). Particularly for smoking cessation, exercise has been shown to be beneficial; however, in the fields of problematic alcohol and illicit substance use and severe substance use disorder, more research is needed to provide scientific evidence beyond initial assumptions and preliminary data (Klamert, Bedi, et al., 2023).

Zschucke et al. (2012) investigated numerous international studies using any form of exercise as a specific therapeutic strategy within substance use treatment to extract information on reported mechanisms which explain the effect of exercise on substance use and other psychiatric disorders. Based on their findings, they proposed several mechanisms through

which physical activity may affect substance consumption, including neurochemical alterations through exercise, reduction of craving, reduction of stress reactivity, endogenous reward, mood regulation and reduction of symptoms of anxiety or depression. Other proposed mechanisms are social or group support, coping and maladaptive cognitions.

Linke and Ussher (2015) describe three primary pathways by which physical activity may reduce substance use, reduce cravings and improve relapse prevention, including psychological, behavioural and neurobiological pathways. From a psychological perspective, physical activity may reduce withdrawal symptoms, negative affect and substance craving and improve mental health and well-being. Additionally, physical activity may reduce the likelihood of relapse by simultaneously increasing positive affect and decreasing negative affect. On the behavioural pathway, physical activity may provide an easily accessible, sustainable and immediately rewarding alternative to substance use and further trigger other health behaviours that are commonly associated with increased PA, including improved sleep and diet. Psychobiological theories suggest that similar reward pathways are activated during substance use and physical activity, with a comparable pattern of increase in neurotransmitters that are associated with positive feelings.

Finally, a more recent review that aimed to determine the effects of physical activity on the prevention, reduction and treatment of substance use across the lifespan investigated how the type, duration, frequency and intensity (jointly referred to as “dose”) of physical activity may affect the underlying psychological/physical mechanisms of change (Thompson et al., 2020). Due to the limited information provided in the included studies, however, the review could not draw clear conclusions regarding this question, highlighting the need for more research in this area.

Overall, there is initial evidence of several positive treatment effects, which play a role in the positive effect of exercise and physical activity integrated with regular mental health treatments (Simonton et al., 2018; Thompson et al., 2020). However, more research investigating possibly underlying mechanisms is needed to draw causal inferences.

2.4 Conceptual Framework

The emergence and continuation of problematic substance use have been explained by several theoretical perspectives from different disciplines, including behavioural, biological and social theories (Thombs & Osborn, 2019). While different theories contribute to the relevant literature

aiming to explain substance use, the current research project was embedded within a behavioural framework (R. West, 2001), while recognising the value of other theories. Similar to the emergence of substance use, strategies for treatment have also often been described with the help of behavioural theories, such as *negative* and *positive reinforcement* (Oluwoye et al., 2020), or *cognitive-behavioural theories* (Newman, 2019). One behavioural perspective conceptualises substance use as coping behaviour for psychological stress and mental health concerns which is maladaptive long term (Hendy, Black, Hakan Can, Fleischut, & Aksen, 2018; Wang, Burton, & Pachankis, 2018). By comparison, physical activity is conceptualised as a healthy alternative to an unhealthy behavioural strategy (Simonton et al., 2018; Zschucke et al., 2012) and has further shown to positively influence cognitive reappraisal in coping with stressors (Perchtold-Stefan, Fink, Rominger, Weiss, & Papousek, 2020). The conceptual framework aligns with the Consolidated Framework for Implementation Research (see chapter 1.6.4 Consolidated Framework for Implementation Research) which defines behaviour as the result of a person's capability, opportunity, and motivation triggered by a specific need.

2.4.1 Behavioural framework of this research project

In line with a behavioural framework, the research project was guided by the COM-B model of behaviour change (see *1.6.5 COM-B model of behaviour change*). Existing PA interventions were analysed according to applied behaviour change techniques in Phase 1 (see *Chapter 3. Existing evidence: Systematic Review and Meta-Analysis*) and related to commonly known effective mechanisms of behaviour change (such as identified by Michie et al., 2013). In Phase 2, young people's experienced barriers to and needs regarding physical activity participation and interventions were explored (see *Chapter 4. Young People's Expertise: A Mixed Methods Exploration*), and their influence on young people's PA capacity, PA motivation and PA opportunity was discussed. Further, the strategic placement of service interventions was discussed to improve young people's capacity, motivation, and opportunity and nurture these conditions.

2.5 The Importance of Young People's Expertise

Psychological research has a long tradition of power imbalance, which can be overcome using a participatory research design. Power imbalance and dependency of research participants is a known issue in clinical and community-based research (Andress et al., 2020; Heath, Brooks, Cleaver, & Ireland, 2009; Karnieli-Miller, Strier, & Pessach, 2009; Raheim et al., 2016; Scholz,

Gordon, & Treharne, 2021). These asymmetrical power relationships are transparently addressed by involving recipients of a program from the beginning, empowering them, and giving them "tools" to communicate their preferences in a safe environment (such as creative methods).

2.5.1 Participatory research with young people

"From 'experts know and decide everything' to 'we need to decide things together'" (Palmer et al., 2019, p. 247)

Youth participation describes a group of approaches and strategies within the broad field of participatory research which advocates for the meaningful inclusion of young people in the research process. However, as youth participation is said to be a relatively new research area, numerous disparate positions define the field, with a general lack of consensus on the participant group, the definition of participation within the context of youth, and the outcomes aimed for (Cahill & Dadvand, 2018). One definition is provided by B. Checkoway (2011) who describes youth participation as an active engagement of young people, recognising their competency and potential rather than assigning them a passive role, as well as a fundamental right and process involving including young people in important decisions affecting their lives. According to Faithfull, Brophy, Pennell, and Simmons (2019), youth participation further provides insights into specific groups' values, preferences and experiences; ensures that the conducted research is relevant to young people and gives young people agency within youth-related discussions. Existing research further indicates that youth participation may improve overall outcomes for youth (Bower et al., 2023; McCabe et al., 2023).

2.6 Chapter Summary

Chapter 2 provided an overview of different perspectives on young people, as well as described unique phenomena emerging in this age group, including a decline in physical activity and an increase in mental health concerns and risky behaviour, including substance use. Additionally, Chapter 2 provided a conceptual framework for the studies included in this thesis, which ties substance use and physical activity intervention with behaviour change theory and places the research within the overarching CFIR and associated COM-B model of behaviour change. Lastly, the chapter provided detailed insight into the importance of integrating young people's

perspectives into research and providing them meaningful opportunities to share their insights and preferences.

The following *Chapter 3. Existing Evidence: Systematic Review and Meta-Analysis* describes the evidence base on physical activity interventions for young people with substance use and will discuss different intervention formats, applied behaviour change techniques and the importance of integrating intervention development and implementation science.

PHASE 1- EXISTING EVIDENCE

3 Existing Evidence: Systematic Review and Meta-Analysis

3.1 Chapter Introduction

Chapter 3 presents the existing evidence base on physical activity interventions for young people with problematic substance use through three peer-reviewed publications. Publication 1 systematically reviews different physical activity interventions for young people at risk for problematic substance use and critically discusses findings on the effect of PA on substance use outcomes. Publication 2 explores the impact of behaviour change techniques that are used as part of the described interventions on substance use outcomes in young people. The third publication highlights and critically discusses the limited reporting of implementation characteristics as part of the described intervention studies, which is of particular importance for the translation of effective interventions into practice. The Chapter concludes by summarising and consolidating the findings of the three publications (Phase 1) and discussing implications for Phase 2 of the research project.

3.2 Review Background

3.2.1 Rationale

A systematic review was conducted in Phase 1 to determine the existing evidence base for subsequent research (Phases 2 and 3) and investigate published physical activity interventions for young people with problematic substance use. Systematic reviews represent a reliable strategy for both researchers and clinicians to identify summarised and distinct effect sizes within many international studies. By adhering to a transparent, published protocol, a systematic review additionally allows other members of the scientific community to reconstruct steps and reduces the risk of bias (Uman, 2011; Wilczynski, 2017).

3.2.2 Review aims

Existing reviews on physical activity interventions for substance use reduction in young people predominantly applied a traditional conceptualisation of development according to which the age of 18 years signifies distinctive change and transition to adulthood (Simonton et al., 2018;

Thompson et al., 2020). However, according to a more contemporary conceptualisation, the age period of 18-25 years is characterized by extensive development and prolonged transition prior to adulthood, including identity exploration (Tanner & Arnett, 2016). As most mental disorders develop before the age of 25, the age period further holds significance for the diagnosis, pathogenesis and early intervention for many mental disorders, suggesting a transition away from an arbitrary distinction of adolescence and adulthood towards a new youth mental health paradigm (Uhlhaas et al., 2023).

To reflect the contemporary definition of youth mental health and young people, the current review focused on young people aged 12-25 years and aimed to inform researchers and clinicians of the effects and interventions that have been developed for and tested in this population.

In detail the review aimed to:

1. Investigate different formats of physical activity interventions for substance use in adolescents and young adults aged 12-25 years who are at particular risk of problematic substance use,
2. Explore behaviour change techniques that were associated with the investigated interventions and their effect on substance use outcomes in young people,
3. Identify implementation characteristics that were reported in the identified studies.

The conceptualisation of young people as "at-risk" applied in this review included both young people with regular use (no known SUD) and known risk populations (e.g., low socioeconomic background, ethnic minorities, and young people with serious mental illness). While the inclusion and exclusion of populations depends on how the concept is conceived by different researchers (Sussman & Sinclair, 2022), the concept of an "at-risk" population is crucial in substance use research as these populations hold much potential for early intervention before the development of a threshold substance use disorder. Populations commonly defined as such in research and clinical practice were included (for 'at-risk', see chapter *1.3.1 Early intervention in at-risk populations)*.

Due to the comprehensive nature of this systematic review, including several qualitatively different sub-aims, the outcomes were separated into three peer-reviewed publications, focussing on the effect of PA interventions on substance use (Publication 1), the effect of using behaviour change techniques as part of the trialled interventions (Publication 2) and the limited reporting of factors referring to the implementation of interventions

(Publication 3). These published studies form the basis of this Chapter. Supplementary tables for Publication 1 and 3, including the risk of bias assessment, excluded studies and the search strategy can be found in Appendix A (Appendices A.2-A.7).

3.2.3 Review process

A systematic review in health sciences follows several steps, which are commonly performed independently by two researchers. These steps include: formulation of the review question(s); definition of inclusion and exclusion criteria; development of an appropriate search strategy; study selection and study extraction; assessment of study quality and small study bias; as well as synthesis, analysis, and interpretation of results (Uman, 2011).

To begin, a prospective research protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO), which listed detailed information on the planned review process (registration number CRD42021225252, Appendix A.1). Four databases (PsycINFO, CINAHL, SPORTDiscus, Scopus, and Medline) were searched for relevant journal articles that reported on physical activity interventions for young people aged 12-25 years with problematic substance use. Other additional searches included hand searches, searches of grey literature, reviewing the reference lists of seminal publications on physical activity interventions for substance use and use of the Orygen Evidence Finder tool[1], an open-access evidence database listing controlled trials within the area of youth mental health (De Silva, Bailey, Parker, Montague, & Hetrick, 2018; Hetrick, Parker, Callahan, & Purcell, 2010).

All studies reporting on physical activity interventions for young people (aged 12-25 inclusive) at risk for problematic substance use which reported on substance use outcomes were included. In addition to efficacy data, study and intervention characteristics, data relating to implementation characteristics that are relevant to the 'implementability' of studies (as defined by Klaic et al., 2022) were extracted, along with methods of behaviour change ("behaviour change techniques'). A meta-analysis was performed to investigate the effect of behaviour change techniques, which have been reported as part of PA interventions, on substance use outcomes in young people.

[1] https://orygen.org.au/Training/Evidence-Finder

'Implementability' of studies refers to intervention features, including implementation strategies and barriers, indicators of feasibility, and acceptability of interventions among non-research personnel (Klaic et al., 2022). Implementation strategies and barriers refer to a set of techniques which either aim to enhance the implementation of interventions (i.e., self-sustaining interventions) or hinder it (i.e., a challenging political context or logistical issues) (Curran, Bauer, Mittman, Pyne, & Stetler, 2012; Powell et al., 2015).

3.3 Efficacy of PA Interventions: Publication 1

Declaration of co-authorship and co-contribution: Papers incorporated in this thesis

1. Publication details

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I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

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In the case of the above publication, the following authors contributed to the work as follows:

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Physical activity interventions for young people with increased risk of problematic substance use: A systematic review including different intervention formats

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ABSTRACT

Objective: This systematic review investigates physical activity (PA) interventions for (1) reducing substance use and associated outcomes, (2) increasing physical activity, and (3) improving mental health in young people aged 12–25 years at increased risk for problematic substance use.
Method: Four databases (PsycINFO, CINAHL, SPORTDiscus, and Medline) and grey literature, including hand searches, were searched (2021–2022). Non-randomized controlled or randomized controlled trials of a) multimodal or unimodal, short or long-term physical activity interventions in young people at increased risk of problematic substance use that b) investigated substance use outcomes were included. PA and mental health outcomes were explored where possible.
Results: Sixty-one percent of the studies (k = 17/28) reported a significant improvement in outcomes related to tobacco (e.g., abstinence, cravings, withdrawal symptoms, smoking pattern), alcohol (e.g., quantity, frequency), or other substance use (e.g., frequency, quantity, recent use). Eight studies reported an increase in PA participation; two reported a beneficial effect on depression symptoms. The certainty of the evidence, i.e., the confidence in the reported effect estimates, was downgraded based on the risk of bias assessment. Findings should therefore be interpreted cautiously.
Conclusions: A range of physical activity intervention formats and modalities may decrease substance use and associated outcomes and increase physical activity participation among people at risk for problematic substance use. Future research is warranted to better establish efficacy and investigate the effectiveness of implementing physical activity as part of treatment for substance use in young people.

1. Introduction

The use of substances including alcohol, tobacco, cannabis, cocaine, and amphetamine peaks during adolescence and young adulthood (Degenhardt et al., 2016). Globally, 16% of men and 15.3% of women between the ages of 15 and 24 years report lifetime substance use (United Nations Department of Economic and Social Affairs (UN DESA), 2019; United Nations Office on Drugs and Crime (UNODC), 2021).

Problematic substance use – defined as use that causes health, social, legal, or other problems (Schlag, 2020; Seddon, 2010)– is associated with comorbid mental illness, cognitive impairment (Guerri & Pascual, 2019; Morin et al., 2019; Thorpe et al., 2020), high-risk behaviors such as intentional self-harm (Bousoño et al., 2017) and sexual risk-taking (Green et al., 2017).

Substance use initiation commonly occurs during adolescence (ages 12–18) (Chaplin et al., 2018; Helzer et al., 1991), with the frequency and amount of use, and the associated harms, reaching their peak in young adulthood (ages 18–25) (Degenhardt et al., 2016; McGorry et al., 2007). During adolescence and young adulthood, important trajectories for later life are established. Substance use may disrupt important

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developmental transitions in social, physiological, neurobiological, and cognitive domains (McGorry et al., 2007), leading to poor social and health outcomes throughout the life course (Degenhardt et al., 2016; Hall et al., 2016). Consequently, problematic substance use in youth should be prioritized within the global health agenda (Castelpietra et al., 2022; Degenhardt et al., 2016), with a focus on early intervention (Chaplin et al., 2018; Stockings et al., 2016). Early intervention aims to reduce substance use before it escalates in young people who may be at-risk or show signs of problematic substance use (Stockings et al., 2016). Many "at-risk" populations for problematic substance use, some identified by Degenhardt et al. (2016) as young people from racial minorities, those with mental illnesses, and from low socioeconomic position or history of early adolescent use, remain understudied (Stockings et al., 2016) despite a plethora of research highlighting their risk status (Rhodes et al., 2003; Sussman & Sinclair, 2022).

There are several treatment approaches targeting problematic substance use in young people, including family-based treatments, motivational enhancement therapy (MET), pharmacological treatments, cognitive behavioral therapy (CBT), and 12-step programs (Austin et al., 2016; Fadus et al., 2019; Hammond, 2016; Hogue et al., 2018; Winters et al., 2018). Yet, these models have limited efficacy (Chung & Maisto, 2006; Ciesla, 2010; Cornelius et al., 2003; Hogue et al., 2018; Winters et al., 2018), may not be appropriate for early intervention, and commonly require young people to identify their substance use as problematic (Hofmann, 2012). With limited effective early interventions for this population (Stockings et al., 2016), there is a clear need for accessible intervention options that may engage young people in alternative ways.

Physical activity, defined as "any bodily movement produced by skeletal muscles that requires energy expenditure" (World Health Organization, 2020), appears to improve substance use-related outcomes such as substance withdrawal symptoms in young people (Lynch et al., 2013; Parker et al., 2016; Smith & Lynch, 2012; Werch et al., 2005), while also increasing physical and mental health more broadly (Babic et al., 2014; Bailey et al., 2018; Carter et al., 2021; Lubans et al., 2012; Parker et al., 2016). Biopsychosocial mechanisms used to explain this effect include a PA-induced activation of dopaminergic brain reward systems, using physical activity as a coping strategy, or the beneficial effect of exercise on cognitive functioning (Abrantes & Blevins, 2019).

Physical activity interventions comprise a range of different approaches targeting the perception, consciousness, behavioral, and cognitive constructs relating to physical activity (Woods et al., 2002), with the latter being of particular relevance for promoting physical activity among those who are considering increasing their physical activity (Marcus et al., 1997). Particularly, the provision of psycho-education and physical activity messages are commonly recommended (Heath et al., 2012).

Although a recent systematic review (Simonton et al., 2018) examined the effect of physical activity interventions on substance use in adolescents, details in several key domains were not reported according to the AMSTAR 2 review appraisal tool (Shea et al., 2017).

Another comprehensive quantitative review (Thompson et al., 2020), and qualitative companion piece (Horrell et al., 2020), investigated different prevention approaches in adolescents and intervention approaches in adults, however, they did not address the particular at-risk period of young adulthood, and the focus in adolescents was on prevention (i.e., before onset of substance use), which can be differentiated from early intervention (see Stockings et al., 2016). The current review focused on early intervention in young people, comparing different intervention formats.

While young people (including adolescents and young adults) record the highest rates of substance use compared to any other age group (United Nations Office on Drugs and Crime, 2022), young adulthood particularly is the peak age range of problematic use and thus needs to be included in reviews. This review further aimed to encompass all relevant approaches to early (physical activity) intervention. These include but are not limited to behavioral and cognitive strategies as well as informational approaches as suggested by the Lancet Physical Activity Working Group (Heath et al., 2012). The interventions can take different formats, i.e., long-term or short-term (single-session/single-bout) interventions; they can be multimodal interventions (i.e., two or more combined intervention approaches targeting physical activity and/or another health behavior such as eating behaviors), or single-modal "unimodal" (i.e., a single intervention targeting PA). By encompassing this range of formats and modalities, this review establishes a more comprehensive synthesis of physical activity interventions than previously undertaken (e.g., Simonton et al. (2018)) and critically discusses the potential of different intervention formats or modalities that could be integrated into substance use treatment practice. The age range (12–25 years) was based on previous research indicating a particularly high prevalence of substance use and mental ill-health in this age group (McGorry et al., 2007; United Nations Office on Drugs and Crime, 2020); it is also consistent with current evidence about neurobiological development suggesting increased susceptibility to stimulation of the brain reward cycle in this age group, which results in increased impulsive and risky behavior compared to other age groups (Kim-Spoon et al., 2017; Nock et al., 2017).

1.1. Objectives and aims

This review investigated the effects of different formats of physical activity interventions on substance use outcomes, physical activity, and mental health in young people at increased risk for problematic substance use.

By "at-risk" we refer to young people with regular substance use (e.g. regular smokers, regular cannabis users), as well as young subpopulations known to be at risk of problematic substance use e.g., indigenous minorities, young people with mental illness, and/or of low socioeconomic position (see also Degenhardt et al., 2016; Rhodes et al., 2003; Stockings et al., 2016; Sussman & Sinclair, 2022). The review focused on early intervention in the critical risk period between the age of onset of substance use in adolescence to the development of problematic substance use in young adulthood, with the population of interest being young people aged 12–25 years.

Physical activity interventions that were unimodal or multimodal, including behavioral, cognitive, and informational approaches, comprised the independent variable. Substance use outcomes (i.e., frequency and amount of use, intent to use, withdrawal symptoms, craving), and if reported physical activity participation, and mental health (including stress and depression symptoms) were the dependent variables.

2. Method

2.1. Protocol

A review protocol was registered with PROSPERO (registration number CRD42021225252). The background and aims, population of interest, anticipated data extraction, and proposed synthesis methods were described *a priori*. No deviations from the protocol were recorded.

2.2. Information sources

The search was conducted between November 2020 and January 2021 and updated in November 2022 according to the original search criteria. Four databases (PsycINFO, CINAHL, SPORTDiscus, and Medline) were searched for articles reporting on physical activity interventions focusing on any construct relating to physical activity and

applying various approaches (i.e., cognitive, behavioral, informational) including physical activity-promoting educational programs for young people at risk for problematic substance use. All findings were cross-referenced with the Evidence Finder Tool open online database (https://orygen.org.au/Training/Evidence-List). Grey literature and manual hand searches were conducted to identify additional eligible studies, including previously published reviews (Linke & Ussher, 2015; Simonton et al., 2018), seminal publications on substance use and physical activity in young people (e.g., Kwan et al., 2012), and reference lists.

All peer-reviewed publications up to December 2023 in the English language were eligible for inclusion. Terms related to either the population (e.g., youth, young people), the intervention of interest (e.g., physical activity, exercise), general intervention-related terms (e.g., program, intervention, treatment), and substance use (e.g., drugs, addiction, substance misuse) were combined using the boolean operators AND/OR. The search strategy used a combination of appropriate index terms (Thesaurus), subject headings (CINAHL), meSH terms (Medline), and free text terms. All populations within the age range that are known to be at risk for problematic substance use were considered. As some studies included broader age ranges than were of interest in this review, studies were deemed eligible if the mean participant age fell between 12 and 25 years. The risk of reduced applicability by including studies that had some ineligible participants was judged as preferable compared with the data loss if these studies were excluded.

2.3. Study inclusion and exclusion criteria

Where multiple publications were derived from the same study, these publications were treated as one study. For a detailed list of inclusion and exclusion criteria see Table 1.

2.4. Study selection

The search strategy, including the original and updated search, identified 5427 records. After removing duplicates, 5049 abstracts were screened and 180 full texts were assessed. All studies were imported into Covidence (www.covidence.org). Study selection was performed independently by different combinations of two reviewers for abstracts and full-texts, with a third researcher for consensus if needed. All researchers had extensive research experience in one or more investigated areas and/or systematic reviews in these areas.

2.5. Data collection and analysis

Data of interest included descriptions of physical activity interventions to reduce substance use outcomes and increase physical activity in young people at risk for problematic substance use. Substance use outcomes of interest were (1) participants' substance use behavior (e.g., frequency, amount, and type of substance use); (2) self-reported intent to use a substance in the future; (3) urges (cravings or strength of desire) to use a substance; (4) withdrawal symptoms when not using the substance; and (5) self-reported symptoms associated with substance use disorder (e.g., impaired control over substance use). Other outcomes were (6) physical activity participation (e.g., levels or frequency of physical activity), attitudes towards physical activity, physical fitness, and (7) mental health: symptoms of mental illness (e.g., depression and anxiety) (see also registered protocol).

Other data of interest included participant and intervention characteristics. Data collection and extraction were performed in duplicate. The research team piloted the data extraction form to ensure uniformity and consistency. Any discrepancies in data extraction were discussed and resolved by at least two researchers and a third if necessary. If a reviewer was an author on any of the studies, they did not perform either primary or secondary data extraction or risk of bias assessment on that study. In studies where the promotion of physical activity, which is the focus of this review, was the 'control condition', the control condition was treated and assessed as the experimental condition. Due to large heterogeneity in measurement tools, outcomes, and study designs, no meta-analysis was conducted. Missing data were addressed by contacting corresponding authors.

2.6. Risk of bias assessment

Risk of bias assessment was completed for each study using the Cochrane risk of bias assessment tool for randomized studies (RoB 2, Higgins et al., 2021) and Cochrane recommendations for risk of bias assessment for non-randomized studies (ROBINS-I, Sterne et al., 2021). Risk of bias assessment was completed independently by at least two researchers. Any discrepancies in judgment were resolved by consensus or the involvement of a third researcher.

The certainty and confidence in the body of evidence were assessed with the GRADE approach (GRADE Working Group., 2004; Guyatt et al., 2008). No studies were excluded based on their GRADE rating, as the purpose of the review was to provide a comprehensive analysis of the existing evidence.

2.6.1. Openness and transparency

The review authors report how they determined study selection, all data exclusions (if any), all manipulations, and all measures in the study. The review was conducted following the APA Reporting Standards for Studies Using No Experimental Manipulation (JARS) (https://apastyle.apa.org/jars) (Appelbaum et al., 2018). All measures and detailed risk of bias data are available upon request.

3. Results

3.1. Study selection

For study selection and flow see Fig. 1.

Table 1
Criteria for study/manuscript inclusion or exclusion in the review.

Inclusion criteria	Exclusion criteria
• Participant group: Young people (mean age between 12 and 25 years) known to be at increased risk of problematic substance use (ie., substance use that is associated with health and/or social problems and/or legal problems) • Intervention: Physical activity interventions applying cognitive, behavioral, or informational approaches including comprehensive multimodal interventions, single-bout, acute studies and educational/informative interventions • Presence of a control group (active or inactive) • Outcomes of interest: Substance use outcomes (e.g., frequency of substance use, craving/urges to use, amount of use) • Randomized controlled trials (RCT) or non-randomized studies (NRS) • Peer-reviewed	• Publication language not English • Protocols of prospective study reports • Unpublished doctoral theses • Conference abstracts

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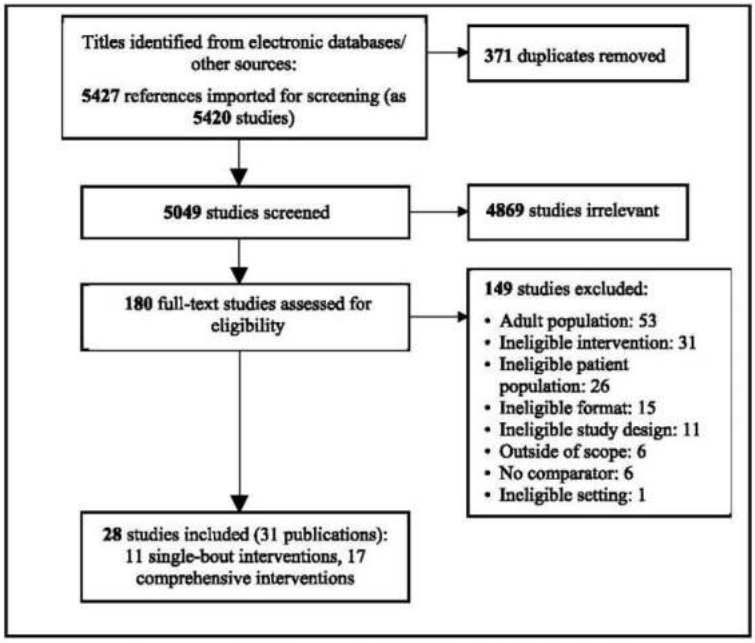

Fig. 1. PRISMA flow diagram of study selection (original and updated).

3.2. Overall study characteristics

A total of 31 publications reporting on 28 studies were included in the systematic review (where one study yielded several publications, only the original is cited). The study designs included 16 randomized controlled trials (An et al., 2013; Correia et al., 2005; Fishbein et al., 2016; Horn et al., 2011; Kerr et al., 2013; Lane et al., 2012; Melamed et al., 2022; Murphy et al., 1986; Parker et al., 2016; Prince et al., 2020; Rotheram-Borus et al., 2016; Scott & Myers, 1988; Stanley et al., 2017; Weinstock et al., 2014, 2016; Ybarra et al., 2013), three non-randomized trials (NRS) (Everson et al., 2006; Scott & Myers, 1988; Tesler et al., 2018), four cluster randomized trials (Horn et al., 2011; Lane et al., 2012; Rotheram-Borus et al., 2016; Stanley et al., 2017), and five crossover designs (Faulkner et al., 2010; Janse Van Rensburg & Taylor, 2008; Oh & Taylor, 2014; Taylor et al., 2005; Wilson et al., 2018) (Supplementary Tables 1 and 2).

3.2.1. Differentiation according to intervention format

Interventions included a cluster of short-term, acute interventions predominantly investigating efficacy (k = 11, see Supplementary Table 1) (Daniel et al., 2006, 2007; Everson et al., 2006, 2008; Faulkner et al., 2010; Ho et al., 2014; Janse Van Rensburg & Taylor, 2008; Oh & Taylor, 2014; Prapavessis et al., 2014; Taylor et al., 2005; Wilson et al., 2018) and comprehensive, long-term interventions investigating effectiveness (k = 17, see Supplementary Table 2) (An et al., 2013; Correia et al., 2005; Fishbein et al., 2016; Horn et al., 2011; Kerr et al., 2013; Lane et al., 2012; Melamed et al., 2022; Murphy et al., 1986; Parker et al., 2016; Prince et al., 2020; Rotheram-Borus et al., 2016; Scott & Myers, 1988; Stanley et al., 2017; Tesler et al., 2018; Weinstock et al., 2014, 2016; Ybarra et al., 2013). Efficacy hereby referred to controlled trial environments; effectiveness trials in turn tested the intervention outcomes in 'real-life' environments (Revicki & Frank, 1990; Singal et al., 2014). Studies included both unimodal approaches, i.e., applying one interventional approach, and multimodal approaches targeting health behavior via two or more combined therapeutic approaches. The combined mean age of participants was 20.7 years across the 28 studies; the overall sample (N = 5523) identified as predominantly female (59.1%); 40.9% identified as male.

3.3. Acute, short-term interventions

Acute, short-term studies (k = 11) exclusively used unimodal, behavioral approaches, comprising 15–30 min interventions involving 1–2 sessions on a cycle ergometer or treadmill with immediate measurement of outcomes after the intervention. While these interventions predominantly targeted a single behavior (i.e., substance use), one focused on more than one behavior, i.e. substance use and eating behavior (Oh & Taylor, 2014).

Longer-term maintenance of behavior was not assessed after these short-term interventions. Intervention duration ranged from 10 to 15 min with immediate post-intervention assessments at "Immediate Post" (IP), 5 min, 10 min, and up to 30 min post-intervention. Details on study characteristics of acute, short-term interventions can be found in Supplementary Table 1.

3.3.1. Samples

Samples for short-term interventions were drawn from community and educational settings with a single study recruiting within a partly clinical population (Prapavessis et al., 2014). The overall sample (N = 339) had a mean age of 22.8 years and was predominantly male (56.3%); 43.7% identified as female. Short-term studies predominantly focused on regular cigarette smokers, with one study focusing on regular cannabis users (Wilson et al., 2018).

3.3.2. Substance use outcomes

Data on substance use as assessed in short-term studies included a variety of self-reported outcomes for tobacco and cannabis use, including short-term abstinence from cigarette smoking (time to first puff) (Faulkner et al., 2010), tobacco withdrawal symptoms (Daniel et al., 2006, 2007; Everson et al., 2006, 2008; Prapavessis et al., 2014),

desire to smoke cigarettes (Daniel et al., 2006, 2007; Everson et al., 2006, 2008; Janse Van Rensburg & Taylor, 2008; Oh & Taylor, 2014; Taylor et al., 2005), intentions to smoke (Janse Van Rensburg & Taylor, 2008), puff volume and puff duration (tobacco) (Faulkner et al., 2010), attentional bias for smoking cues (tobacco) (Oh & Taylor, 2014), baseline consumption frequency (cannabis) (Wilson et al., 2018), and cravings for tobacco (Prapavessis et al., 2014) and cannabis (Wilson et al., 2018) All included studies reported on use of a single substance. A detailed description of measurement tools used for assessing substance use can be found in Supplementary Table 1.

Almost 73% of the included unimodal, short-term studies (8 out of 11 acute interventions) reported a significant improvement in post-intervention substance use outcomes compared to the control conditions (Daniel et al., 2006, 2007; Everson et al., 2008; Faulkner et al., 2010; Janse Van Rensburg & Taylor, 2008; Oh & Taylor, 2014; Prapavessis et al., 2014; Taylor et al., 2005). For tobacco use, these effects included increased time of smoking abstinence (measured as "time to first puff") (Faulkner et al., 2010), reduction in intent to smoke (Janse Van Rensburg & Taylor, 2008), reduction in attentional bias for smoking (Oh & Taylor, 2014), and decreased desire to smoke/tobacco cravings and tobacco withdrawal symptoms (Daniel et al., 2006, 2007; Everson et al., 2008; Janse Van Rensburg & Taylor, 2008; Prapavessis et al., 2014; Taylor et al., 2005). No significant effect (i.e., decrease in craving) was found for cannabis use (Wilson et al., 2018).

3.3.3. Physical activity

Overall, all short-term interventions facilitated individual, in-person, and supervised physical activity engagement. The nature of physical activity elements included acute exercise bouts of brisk walking on a treadmill or cycle ergometer and text-based promotion of physical activity prior to exercise bouts. Detailed descriptions of short-term intervention characteristics are in Supplementary Table 3 in line with TIDieR (template for intervention description and replication, Hoffmann et al., 2014). Control conditions included delayed control conditions as comparison groups, low-intensity exercise, or passive controls.

No studies identified as "acute, short term" reported on post-intervention physical activity outcomes.

3.3.4. Mental health

Depression symptoms were assessed in 4 short-term interventions (Daniel et al., 2006, 2007; Everson et al., 2006, 2008), one of which found significant decreases in depression symptoms after participating in a physical activity intervention (Daniel et al., 2007).

3.4. Long-term interventions

Long-term interventions included unimodal approaches (k = 8) (Correia et al., 2005; Fishbein et al., 2016; Kerr et al., 2013; Lane et al., 2012; Murphy et al., 1986; Scott & Myers, 1988; Stanley et al., 2017; Ybarra et al., 2013), i.e., applying one interventional approach, and multimodal approaches (k = 9) targeting one or more health behaviors via different theoretical channels (An et al., 2013; Horn et al., 2011; Melamed et al., 2022; Parker et al., 2016; Prince et al., 2020; Rotheram-Borus et al., 2016; Tesler et al., 2018; Weinstock et al., 2014, 2016). For instance, Horn et al. (2011) applied two different therapeutic/behavioral approaches to reduce substance use and increase physical activity using an informational/educational approach (i.e., smoking cessation curriculum) paired with a behavioral approach (i.e., step-counting challenge using a pedometer). This approach differs from Fishbein et al. (2016) and Scott and Myers (1988) who each only used a single therapeutic (behavioral) approach (i.e., yoga or fitness training, respectively) to reduce substance use behavior.

Compared to acute interventions, long-term interventions predominantly targeted multiple health behaviors (e.g. substance use, physical activity participation, eating behaviors), with only three studies assessing substance use exclusively (Murphy et al., 1986; Prince et al., 2020; Ybarra et al., 2013).

Intervention duration in long-term studies ranged from several weeks up to 12 months with immediate post-intervention and some studies included follow-up assessments several weeks after intervention completion to assess the maintenance of behavior. For details see Supplementary Table 2.

3.4.1. Samples

Similar to acute interventions, the combined sample of long-term interventions (N = 5192) was predominantly drawn from educational settings; five studies recruited participants from community settings (Kerr et al., 2013; Melamed et al., 2022; Prince et al., 2020; Rotheram-Borus et al., 2016; Tesler et al., 2018), and two studies each recruited within clinical settings (Melamed et al., 2022; Parker et al., 2016) and online settings (An et al., 2013; Ybarra et al., 2013), respectively. The sample was predominantly female (60.1%); 39.9% identified as male. The mean age (19.4 years) was slightly younger than that in acute intervention studies. Sample sizes ranged from eight (Ho et al., 2014) to 1654 participants (Kerr et al., 2013).

The long-term studies focussed on the following populations of young people at increased risk for problematic substance use: regular cigarette smokers or users of another substance (An et al., 2013; Correia et al., 2005; Horn et al., 2011; Prince et al., 2020; Ybarra et al., 2013), hazardous drinkers or at risk for binge drinking (Murphy et al., 1986; Weinstock et al., 2014, 2016), young men affected by alcohol use and violence (Rotheram-Borus et al., 2016), at-risk youth populations with high-risk behavior (Fishbein et al., 2016; Lane et al., 2012; Stanley et al., 2017; Tesler et al., 2018) and/or mental illness (Melamed et al., 2022; Parker et al., 2016) and young members of ethnic minorities and low socioeconomic position at known risk for substance use (Kerr et al., 2013; Scott & Myers, 1988). Drop-out rates varied substantially across studies, ranging from 3.7% (Correia et al., 2005) to 48% (Murphy et al., 1986). Reasons for drop-outs included condition assignment (Murphy et al., 1986), lack of motivation (Rotheram-Borus et al., 2016), severity of comorbid mental illness (Melamed et al., 2022), and mental health symptom improvement (Parker et al., 2016).

3.4.2. Substance use outcomes

Self-reported substance use outcomes (i.e., tobacco, alcohol, and other substances) in long-term interventions included: frequency of use, amount of use, attitudes towards use, and quit rates. More than half of the studies (k = 9) investigated polysubstance use (An et al., 2013; Correia et al., 2005; Fishbein et al., 2016; Kerr et al., 2013; Melamed et al., 2022; Parker et al., 2016; Rotheram-Borus et al., 2016; Scott & Myers, 1988; Tesler et al., 2018), i.e., measured more than one substance (including alcohol, tobacco, and other substances). The remaining studies reported exclusively on tobacco (k = 3) (Horn et al., 2011; Stanley et al., 2017; Ybarra et al., 2013), alcohol use outcomes (k = 4) (Lane et al., 2012; Murphy et al., 1986; Weinstock et al., 2014, 2016), or cannabis use (k = 1) (Prince et al., 2020). A detailed description of the measures used to assess substance use can be found in Supplementary Table 2.

Overall, study findings indicated that various long-term physical activity interventions, including multimodal and unimodal approaches, may reduce substance use and/or improve associated outcomes. Assessed substance use outcomes included: abstinence from cigarette smoking or quit rates (An et al., 2013; Horn et al., 2011; Ybarra et al., 2013), consumption frequency (tobacco, cannabis, alcohol, other substances) (An et al., 2013; Correia et al., 2005; Fishbein et al., 2016; Kerr et al., 2013; Lane et al., 2012; Melamed et al., 2022; Murphy et al., 1986; Parker et al., 2016; Prince et al., 2020; Scott & Myers, 1988; Tesler et al., 2018; Weinstock et al., 2014, 2016), attitudes towards tobacco use (Stanley et al., 2017), recent substance use (methamphetamine, cocaine, heroin) (Rotheram-Borus et al., 2016), and cravings (cannabis) (Prince et al., 2020).

Slightly more than half (52.9%) of the long-term interventions (9 out

of 17) reported a significant improvement in one or more substance use outcomes post-intervention compared to the control conditions (An et al., 2013; Correia et al., 2005; Horn et al., 2011; Murphy et al., 1986; Parker et al., 2016; Prince et al., 2020; Rotheram-Borus et al., 2016; Scott & Myers, 1988; Tesler et al., 2018). These effects included increased days of smoking abstinence or quit rates (An et al., 2013; Horn et al., 2011) or reductions in daily cigarettes smoked (Tesler et al., 2018). For other substance use, findings reported a decrease in quantity or frequency of reported alcohol consumption (An et al., 2013; Murphy et al., 1986; Tesler et al., 2018), cannabis use frequency/quantity (Parker et al., 2016; Prince et al., 2020), and other substance use frequency including methamphetamine use (Correia et al., 2005; Rotheram-Borus et al., 2016; Scott & Myers, 1988).

Long-term interventions reporting significant improvements in substance use outcomes were predominantly unsupervised (k = 6 of 9) (An et al., 2013; Correia et al., 2005; Horn et al., 2011; Murphy et al., 1986; Parker et al., 2016; Prince et al., 2020) with in-person contact (k = 9 of 9) (An et al., 2013; Correia et al., 2005; Horn et al., 2011; Murphy et al., 1986; Parker et al., 2016; Prince et al., 2020; Rotheram-Borus et al., 2016; Scott & Myers, 1988; Tesler et al., 2018) with group (k = 5 of 9) (Horn et al., 2011; Murphy et al., 1986; Rotheram-Borus et al., 2016; Scott & Myers, 1988; Tesler et al., 2018) or individual facilitation (k = 4 of 9) (An et al., 2013; Correia et al., 2005; Parker et al., 2016; Prince et al., 2020). Similar to short-term interventions, effect sizes were commonly not reported.

Only four of the long-term interventions reporting a significant reduction in substance use outcomes conducted follow-ups (up to 6 months post-intervention) (An et al., 2013; Horn et al., 2011; Murphy et al., 1986; Prince et al., 2020), thus it was not possible to establish overall maintenance of behavior. For detailed findings see Supplementary 2.

3.4.3. Physical activity

All long-term studies reported on elements of physical activity or physical activity promotion; nonetheless, they differed in the extent, nature, and execution of the described physical activity elements. More than half of identified long-term studies (k = 17) delivered physical activity promotion through group sessions (k = 9 of 17) (Fishbein et al., 2016; Horn et al., 2013; Kerr et al., 2013; Lane et al., 2012; Murphy et al., 1986; Rotheram-Borus et al., 2016; Scott & Myers, 1988; Stanley et al., 2017; Tesler et al., 2018), with the remaining (k = 8) delivered as individual sessions (An et al., 2013; Correia et al., 2005; Melamed et al., 2022; Parker et al., 2016; Prince et al., 2020; Weinstock et al., 2014, 2016; Ybarra et al., 2013). The nature of physical activity elements included various types of physical activity, knowledge building and skills improvement, and avatar or text-based promotion of physical activity. Active and passive conditions were used as control groups, including waitlist controls, treatment as usual, or delayed control conditions as comparison groups; three studies used both active and passive controls (Correia et al., 2005; Fishbein et al., 2016; Murphy et al., 1986). Detailed descriptions of intervention characteristics are in Supplementary Table 4 and in line with TIDieR.

Post-intervention physical activity outcomes (including weekly exercise frequency, physical activity participation, beliefs about physical activity, physical self-efficacy, and exercise behavior) were assessed in 12 long-term interventions (An et al., 2013; Correia et al., 2005; Horn et al., 2011; Kerr et al., 2013; Lane et al., 2012; Melamed et al., 2022; Parker et al., 2016; Scott & Myers, 1988; Stanley et al., 2017; Tesler et al., 2018; Weinstock et al., 2014, 2016), eight of which (66.7%) reported a significant positive effect of the intervention on physical activity or associated outcomes (An et al., 2013; Correia et al., 2005; Horn et al., 2011; Melamed et al., 2022; Scott & Myers, 1988; Tesler et al., 2018; Weinstock et al., 2014, 2016). Of these eight studies, six applied multimodal approaches, while only two studies reporting significant results applied unimodal approaches (Correia et al., 2005; Scott & Myers, 1988).

Finally, a single study reported that the physical activity-promoting information led to a decrease in participants' satisfaction with their usual physical activity levels (Stanley et al., 2017).

3.4.4. Mental health

Depression symptoms were assessed in two long-term interventions (Parker et al., 2016; Rotheram-Borus et al., 2016), one of which found significant decreases in depression symptoms after participating in a physical activity intervention (Parker et al., 2016).

3.5. Assessment of internal validity, publication, and reporting bias

Details of the risk of bias assessment can be found in Supplementary Tables 5 and 6 For RCTs, most ratings across domains were either low risk of bias or raised isolated concerns of risk of bias for the included studies. Notably, several studies had an increased risk of bias due to aspects of their design that did not allow for the blinding of participants or personnel (Faulkner et al., 2010; Fishbein et al., 2016; Janse Van Rensburg & Taylor, 2008; Murphy et al., 1986; Oh & Taylor, 2014; Rotheram-Borus et al., 2016; Wilson et al., 2018), which is common in physical activity intervention studies (El-Kotob & Giangregorio, 2018). Based on the GRADE and risk of bias assessment which assessed most studies as overall low risk, the level of evidence was not downgraded for the included RCTs (An et al., 2013; Correia et al., 2005; Daniel et al., 2006, 2007; Everson et al., 2008; Faulkner et al., 2010; Fishbein et al., 2016; Ho et al., 2014; Horn et al., 2011; Janse Van Rensburg & Taylor, 2008; Kerr et al., 2013; Lane et al., 2012; Melamed et al., 2022; Murphy et al., 1986; Oh & Taylor, 2014; Parker et al., 2016; Prapavessis et al., 2014; Prince et al., 2020; Rotheram-Borus et al., 2016; Stanley et al., 2017; Taylor et al., 2005; Weinstock et al., 2014, 2016; Wilson et al., 2018; Ybarra et al., 2013). By Cochrane recommendations, the level of evidence for the included NRS (Everson et al., 2006; Scott & Myers, 1988; Tesler et al., 2018) was downgraded to low (Schünemann et al., 2021), due to the inherent risk of bias associated with lack of randomization.

3.6. Adverse and harmful effects

Three studies reported on adverse effects of the interventions, two of which were short-term interventions reporting adverse mood effects (Everson et al., 2008) and discomfort (Prapavessis et al., 2014). One long-term intervention reported study-related injury (Weinstock et al., 2016).

4. Discussion

This systematic review examined the effect of various physical activity interventions in the context of early intervention on substance use-related outcomes, physical activity, and mental health outcomes (assessed as depression symptoms) in young people aged 12–25 years, at risk for problematic substance use. The review focused on early intervention in this age group, examining all physical activity intervention types with the potential to affect substance use outcomes. Study formats of interest were acute or short-term studies, and long-term interventions, including multimodal and unimodal interventions. Overall, 61% of the included physical activity interventions improved substance use outcomes in young people, including a reduction in the frequency of use, amount of use, intent to use, and/or cravings for alcohol, tobacco, and other substances. While all types of investigated interventions showed potential benefits for substance use outcomes among young people aged 12–25, more than two-thirds of the short-term or acute studies reported significant effects compared to just over half of the long-term studies.

Short-term, acute studies commonly investigate efficacy rather than effectiveness, and as such are often not considered to be included in the group of "traditional interventions". However, with a significantly

smaller amount of organizational and financial resources associated with the delivery of this type of intervention, the clinical implications of these findings for early intervention, that is the potential of acute physical activity bouts to be integrated into clinical substance use treatment services, needs to be considered.

Additionally, multimodal approaches seemed more likely to reduce substance use and increase physical activity (67%, 6 of 9 multimodal studies) than did unimodal approaches (58%, 11 of 19 unimodal studies). While multimodal physical activity interventions appear promising for the reduction of substance use, it remains unclear which intervention elements contributed to the intervention effect.

Further, the reported effects need to be interpreted in light of the overall low quality of the existing evidence. Moreover, it is currently unclear whether the observed effects persist over time, particularly those in short-term studies, as would be preferable in terms of clinical utility.

Significant effects were reported across short-term and long-term studies with varied individual characteristics such as delivery format and intervention duration (See also Supplementary Tables 1 and 2). This suggests that even single bouts of physical activity may have the potential to temporarily disrupt substance use in this population. Findings also suggest that physical activity interventions can be delivered in a range of settings and circumstances by different providers (e.g., trained peers, clinicians, and coaches).

The findings of this review are broadly consistent with previous studies and systematic reviews on the effects of physical activity on substance use outcomes in young people (Linke & Ussher, 2015; Simonton et al., 2018; Zschucke et al., 2012). The current review included 28 studies and a higher mean age of participants of 20.7 years, however, found similar results to the Simonton et al. (2018) review that included fewer studies, did not compare long-term and acute interventions, and had a slightly younger target population. The current review thus captured the peak period of young adulthood associated with the highest risk for problematic substance use (Degenhardt et al., 2016).

The findings further compare to a review by Thompson et al. (2020) who similar to the current review, found a promising trend for short-term effects of physical activity interventions for various substances. However, Thompson et al. (2020) also highlight concerns regarding the inability to quantitatively examine existing physical activity interventions, limits to generalisability of the results, and large heterogeneity of included interventions which were also identified in the current review. In comparison to the current review, which focussed explicitly on young people (referring to at-risk adolescents and young adults aged 12–25 years), the review conducted by Thompson et al. focussed on different age populations, with adolescents being investigated for prevention studies, and adult populations being investigated for approaches focusing on substance use reduction and clinical populations for substance use disorder treatment.

An earlier review by Linke and Ussher (2015) reported a positive impact of physical activity on young people's substance use, finding a superior effect of supervised, group-based interventions. Superiority of supervised interventions has also been found in adult populations (Abrantes & Blevins, 2019). Conversely, the current review found both supervised and unsupervised, and an overall larger number of individual rather than group-based interventions (including both short-term and long-term interventions) to improve substance use outcomes. This could be due to the inclusion of acute, short-term interventions, which were predominantly facilitated as individual sessions.

Similar to the current review, Linke and Ussher highlighted difficulties in drawing conclusions on the characteristics of effective intervention due to the large methodological diversity among studies, emphasizing the complexity of the effect and covariation with participant characteristics, settings, substance type, and physical activity type.

Last, the studies reviewed here showed mixed findings about the effects of physical activity interventions on depression symptoms. This differs from two earlier reviews indicating a positive effect of physical activity interventions on depression in young people (Bailey et al., 2018; Recchia et al., 2023). The difference may be explained by a potential floor effect, i.e., included studies did not recruit participants based on depressive symptoms, and the low number of included studies measuring depression symptoms. Further research focusing on young people with comorbid substance use and depression is needed.

This review has several strengths. The comprehensive search strategy and inclusion criteria, including RCTs and NRS, and different intervention formats (e.g., acute, long-term, multimodal, unimodal) allowed a comprehensive assessment of the evidence base and highlighted the broad scope of different modalities and flexibility of intervention formats with the potential to reduce problematic substance use in young people. Another strength is the focus on early intervention, encompassing both adolescents and young adults at risk for problematic substance use. At-risk populations are of particular relevance to examining interventions in youth mental health, including youth substance use (Nawi et al., 2021; Stone et al., 2012).

Several limitations to this review exist, including the restriction of study inclusion to studies published in the English language, and consequent lack of knowledge on findings in non-English publications; and the inclusion of studies with a small portion of ineligible subpopulations (i.e. where some individuals in the sample were outside the targeted age range). The risk of limited applicability for these subpopulations was balanced with the critical data loss due to excluding these studies. The conceptual lack of clarity within the academic and clinical literature regarding at-risk definitions and the use of the term "at-risk" needs to be critically considered and this current lack of clarity in definition was another limitation of this review (Follesø, 2015; Foster & Spencer, 2010; Tait, 1995).

There are several limitations to the available evidence, including the recruitment of participants in predominantly educational settings, with no clear indication of whether participants were treatment-seeking. It is unclear if a comparable effect for the latter can be inferred from data on young people who were not seeking help for their substance use. Further, participant groups were predominantly drawn from Western-centric countries, thus findings may not be generalizable to non-Western societies. The heterogenous nature of existing evidence poses a significant limitation to comparability (Linke & Ussher, 2015; Simonton et al., 2018; Thompson et al., 2020) and evidence synthesis; no meta-analysis could be conducted to increase explanatory power. Further, the incomplete reporting of relevant data in some studies (e.g., intervention and study characteristics, statistical data, effect size estimates) combined with the methodological diversity, variation in measurement tools and outcomes assessed, and lack of objective measures (previously noted by Simonton et al., 2018; Thompson et al., 2020) means it remains unclear as to which intervention characteristics are most strongly associated with significant changes in substance use, physical activity, or mental health outcomes. Additionally, while physical activity seems to provide a potential approach to address substance use among young people – possibly increasing engagement of populations that are ambivalent regarding their substance use – it is not clear if physical activity can overcome the limitations of existing interventions and treatments that lead to high attrition and treatment failure rates. Additional research and consistent reporting are needed to explore predictors of intervention adherence (Abrantes & Blevins, 2019) and to provide clear guidance on whether and how to implement physical activity interventions into youth substance use and mental health services.

One opportunity to enhance cohesion in reporting and reduce methodological heterogeneity is via consensus regarding a set of gold standard measures for assessing young people's substance use within the international research context. This would allow comparability between different studies and synthesis of a seemingly heterogeneous body of research into more precise estimates of treatment effects than is possible via individual studies. Such estimates are crucial for guiding clinical

decision-making and policy development (Haidich, 2010), as it is rarely possible to draw implications for policy and practice from individual research studies (Durlak & Lipsey, 1991).

Last, several studies did not report on post-intervention physical activity outcomes, however, measuring and reporting the levels of engagement in physical activity is essential to be able to determine the mechanisms of action of the PA interventions.

4.1. Recommendations for future research

Further research addressing the following themes is recommended (some of which overlap with Linke & Ussher, 2015): Superior combinations of intervention characteristics (e.g., different exercise intensities, different delivery modes) to optimize efficacy; integration of physical activity as an adjunct to treatment within existing substance use treatment modalities (rather than as a stand-alone treatment, as in the majority of existing studies); differences in effect between treatment-seeking and non-treatment seeking populations; long-term effects on substance use outcomes of single versus multiple short-term bouts versus longer programs of physical activity at different intensities; behavioral maintenance of found effects for acute interventions over a longer period of time; experienced barriers and professional development needs of clinicians regarding the integration of adjunctive physical activity programs for young people at risk for problematic substance use; the effect of physical activity on newly emerging substance use trends (including novel psychoactive substances); covariates, moderators, and mediators influencing the effect of physical activity promotion interventions; and relationships (correlations, interactions) between participant and intervention characteristics and outcomes require consideration. Lastly, the benefits, advantages and disadvantages, and challenges of integrating different intervention formats into treatment practice should be further explored.

4.2. Implications

This review demonstrates that various formats of interventions, such as interventions using one or more modalities including different physical activities (e.g. weight training, tailored running regimens), but particularly acute, short-term physical activity interventions, may have the potential to improve substance use outcomes (alcohol, tobacco and other) such as reducing the frequency or amount of use, intentions to use, and/or craving in young people at risk for problematic substance use recruited in educational and community settings. The broad diversity of potentially beneficial physicical activity interventions, but especially the short nature of acute interventions, commonly involving few elements and little personnel, suggest flexibility regarding as to how, when and by whom such interventions could be delivered to young people at risk for problematic substance use. Physical activity interventions may provide an accessible, engaging, and motivating treatment avenue for young people who do not identify their substance use as problematic.

Overall, the promising outcomes identified provide initial evidence to support larger, more rigorous, and more systematic investigations of the efficacy of physical activity in reducing substance use and associated problems in young people. Further research should also focus on assessing the effectiveness of these different formats of physical activity intervention as integrated into treatment to reduce substance use in young people.

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Openness and transparency

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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3.4 Impact of BCT on PA Interventions: Publication 2

Declaration of co-authorship and co-contribution: Papers incorporated in this thesis

1. Publication details

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2. Candidate declaration

I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

_____ _____

Signature Date

3. Co-author(s) declaration

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

1. They meet criteria for authorship in that they have participated in the conception, execution or interpretation of at least that part of the publication in their field of expertise;
2. They take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
3. There are no other authors of the publication according to these criteria;
4. Potential conflicts of interest have been disclosed to a) granting bodies, b) the editor

or publisher of journals or other publications, and c) the head of the responsible academic unit; and

5. The original data will be held for at least five years from the date indicated below and is stored at the following location(s): VU Research repository.

Name(s) of co-authors	Contribution (%)	Nature of contribution	Signature	Date
Craike, Melinda	10%	Co-authorship	[redacted]	12-03-2014
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REVIEW

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Behaviour change techniques in physical activity-focused interventions for young people at risk of problematic substance use: A systematic review and meta-analysis

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Abstract

Aim: This systematic review investigates behaviour change techniques in interventions promoting physical activity for young people aged 12–25 years at heightened risk of problematic substance use, and the effect of these techniques on physical activity participation and substance use outcomes.

Methods: Four databases (PsycINFO, CINAHL, SPORTDiscus and Medline) were searched between November 2020 and November 2022 for randomized and non-randomized controlled studies according to inclusion criteria. Meta-analyses were calculated using weighted, standardized averages of effect sizes (Hedges' g).

Results: Twenty-eight studies were included, 14 studies in the meta-analysis (intervention $n = 1328$; control $n = 845$). Reported BCTs included behavioural *instructions*, *social comparison* and *goal setting*. There was a significant effect of behaviour change techniques on combined substance use outcomes, such as cravings and consumption, for interventions reporting multiple behaviour change techniques ($g = -0.33$, $p < .001$, 95% CI [−0.50,−0.16]) or one single behaviour change technique ($g = -1.84$, $p < .001$, 95% CI [−2.89,−0.8]). Limitations include unexplained variance and limited reporting of relevant behaviour change technique data in the included studies.

Conclusion: The results indicate that using behaviour change techniques in interventions that promote physical activity for young people has an effect on substance use. Further research needs to be completed comparing the impact of the number and type of behaviour change technique, and improved reporting of intervention content is required.

KEYWORDS
adolescent, behaviour therapy, exercise, substance-related disorders, Young adult

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1 | INTRODUCTION AND REVIEW RATIONALE

The development of substance use problems in early adulthood has been identified as risk a factor for disrupted future life trajectories (Degenhardt et al., 2016; Hall et al., 2016; McGorry et al., 2007). Problematic substance use has its peak onset during adolescence, a developmental stage characterized by the formation of adult identity and behavioural experimentation (Aggleton et al., 2006; Helzer et al., 1991). Further, adolescence and early adulthood are marked by a decline in adaptive behaviours, such as engagement in physical activity, with young people's physical activity levels consistently falling below international recommendations (Allison et al., 2007; Finne et al., 2011). Consequently, global research has increasingly focused on strengthening and promoting a variety of health-promoting behaviours to improve the life trajectories of young people and mitigate the long-term consequences of problematic behaviours (Linke & Ussher, 2015; Lynch et al., 2013; Smith & Lynch, 2012).

Physical activity behaviour is associated with substance use behaviour (Kwan et al., 2012; Linke & Ussher, 2015; Moore & Werch, 2005), namely an increase in physical activity appears to be associated with lower levels of illicit substance use (Linke & Ussher, 2015). Complex behavioural interventions aim to simultaneously change multiple health behaviours by strategically applying behaviour change techniques targeting explicit and implicit health management (An et al., 2013; Bourke et al., 2022; Brug et al., 2005; Michie et al., 2011). One example is interventions aiming to increase physical activity levels while simultaneously reducing problematic substance use (An et al., 2013). These interventions are based on research indicating that increased physical activity may yield a decrease in reported substance use outcomes in youth (Kirkcaldy et al., 2002; Linke & Ussher, 2015; Moore & Werch, 2005; Simonton et al., 2018) and studies using physical activity prescriptions to both increase physical activity and decrease substance use (Cabrera, 2020; Gustavsson et al., 2018; Kallings, 2016).

1.1 | Behaviour change

Michie et al. have developed taxonomies (i.e. classification systems) to identify and organize behaviour change techniques and their associated mechanisms of change (Michie et al., 2011; Michie et al., 2013; Teixeira et al., 2020; West et al., 2019). By doing so, Michie et al. aim to increase the possibility of identifying effective components within interventions, enhance their replicability and improve both implementation and evidence synthesis (Michie et al., 2011).

The CALO-RE taxonomy, an extension of a previous taxonomy (Abraham & Michie, 2008), identifies 40 different behaviour change techniques (BCTs) extracted from numerous international publications that aim to increase guideline-concordant physical activity behaviour. For more details about the CALO-RE taxonomy, see table 3 in Michie et al. (2011).

A recent review reported favourable outcomes (e.g. reduction in alcohol, opiate and stimulant use) in adult populations for the application of the following BCTs with physical activity interventions targeting substance use: *instruction on how to perform the behaviour*, *social support (unspecified)*, *behavioural practice/rehearsal*, *problem-solving*, *pharmacological support* (i.e. for smoking cessation, as detailed by Hartmann-Boyce et al. (2018)), *goal setting* (behaviour), *self-monitoring* (behaviour) and *biofeedback* (Thal et al., 2022). A meta-analysis was not performed in this review, and it remains unclear if the use of these BCTs in interventions has an effect on younger populations.

1.2 | Review question

Klamert et al. (2023) found evidence for beneficial effects of interventions that promote physical activity on alcohol, tobacco and illicit substance use outcomes in young people aged 12–25 years at heightened risk of problematic substance use. These interventions improved tobacco use, alcohol use and illicit substance use outcomes, including reducing intentions and/or cravings to use substances, and increasing physical activity participation.

This current review reports on the behaviour change techniques that were applied in studies included in the Klamert et al. (2023) review. Accordingly, the current study aimed to:

1. Describe behaviour change techniques reported in interventions that aim to promote or increase physical activity in young people at risk for problematic substance use, according to the CALO-RE taxonomy; and
2. investigate the effect of the number and type of reported behaviour change techniques included in interventions on substance use outcomes and physical activity in young people at risk for problematic substance use.

2 | METHOD

The review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (http://www.prisma-statement.org) and the APA Quantitative Meta-Analysis Article Reporting Standards (MARS) (Appelbaum et al., 2018).

Publications reporting on interventions for young people at risk of problematic substance use that promote physical activity and report on substance use and physical activity participation were considered. Doctoral publications, non-English, protocols, prospective publications and abstracts were excluded.

A review protocol was registered before the literature search, and there were no deviations from this protocol.

The study search was completed in January 2021 and updated in November 2022, using four databases (PsycINFO, CINAHL, SPORTDiscus and Medline), reference lists of relevant publications and existing systematic reviews. Indexed and free text terms were included via Boolean operators.

Abstract and full-text screening, study selection and inclusion were performed in duplicate by researchers experienced in systematic review methods in physical activity and substance use. Studies were considered according to the following inclusion criteria: the studied population was

young people (12–25 years) at risk for problematic substance use (ie., by virtue of low socioeconomic status, socioeconomic disadvantage, high-risk behaviour and comorbid mental illness (Klamert et al., 2023)); intervention type was interventions that promote physical activity; studies included a control group (active or inactive); and studies reported on substance use outcome measures. Studies were eligible for inclusion if interventions either solely focused on physical activity promotion or used physical activity promotion among other intervention elements. The screening was conducted using Covidence (Extraction version 2.0, www.covidence.org, Melbourne)

Intervention and participant characteristics, reported behaviour change techniques and the outcomes of primary (substance use outcomes) or secondary interest (physical activity engagement levels) were extracted by one reviewer and checked by a second reviewer. All reported time points and measures were extracted, including the different measures used to assess a single outcome within a study. Data were reported as weighted, standardized effect sizes (Hedge's *g*).

Analysis and extraction of behaviour change techniques were based on the CALO-RE taxonomy described by Michie et al. (2011). Studies reporting on single BCT interventions were compared to studies reporting on multiple BCT interventions. This approach was consistent with previous research conducted by Michie et al. (2009), investigating interventions that applied very few BCTs to interventions that applied a larger number of BCTs in low-income countries. Findings suggested that different numbers of BCTs may yield different effects on outcomes (Michie et al., 2009).

A risk of bias assessment was completed in duplicate in Covidence for all included studies according to the Cochrane RoB2-tool (Higgins, Savović, et al., 2021) for randomized controlled studies (RCT) and Cochrane ROBINS-I tool (Sterne et al., 2021) for non-randomized studies (NRS), as well as a GRADE rating for determining the certainty of evidence (GRADE Working Group., 2004; Guyatt et al., 2008).

The comprehensive software [("*Comprehensive Meta-analysis*" (version 3) (www.meta-analysis.com)] was used to calculate outcome effects according to a random effects meta-analysis based on reported numerical data (pre/post means, standard deviations (SD), mean changes, sample sizes). Analyses of publication bias, sensitivity and subgroup effect (a priori planned and unplanned) were undertaken for all studies; manual conversions were performed where necessary. Studies were excluded if reported data could not be converted into numerical data relevant for synthesis and raw data could not be obtained from study authors.

Publication bias was explored using funnel plots. Studies with inadequately reported outcomes and missing data that could not be retrieved through manual calculations or contacting respective authors were excluded from the analysis.

2.1 | Openness and transparency

According to MARS, the review authors determined the study selection, all data exclusions (if any), manipulations and measures in the review (Appelbaum et al., 2018). Data and research materials are available upon request.

3 | RESULTS

From 5427 identified records, 28 studies describing a range of different study designs (randomized controlled trials, non-randomized controlled trials, cluster and crossover designs) were included (Figure 1) The mean age of the included population was 20.7 years. Assessed substances included alcohol, tobacco and illicit substances, such as methamphetamine. For exclusion reasons of studies see supplemental list of excluded studies.

3.1 | Behaviour change techniques

Behaviour change techniques for increasing physical activity behaviour were extracted from the included studies. The most frequently used BCT was *providing instruction on how to perform behaviour*. This strategy was reported in 18 of the included studies. The strategies *providing information on the consequences of behaviour in general* and *goal setting* (referring to the behavioural processes of setting goals, rather than the outcome) were reported by 11 of the included studies. Another frequently reported strategy was *facilitating social comparison* to change individual participants' behaviour. The eight most reported BCTs according to their frequency can be found in Table 1. A full list of extracted BCTs, participation rate and reported meintance of behavior change is provided in Table 2.

3.2 | Risk of bias within the included studies

According to the risk of bias assessment for RCTs, the studies and study domains listed in Tables 3 and 4 were rated as high risk.

Based on the risk of bias assessment, the level of evidence and thus confidence in the range of an effect estimate (Schünemann et al., 2021) was rated high for included RCTs, however, the level of evidence was downgraded to low for all included non-randomized trials (NRS).

TABLE 1 Most frequently reported behaviour change strategies in included studies according to CALO-RE taxonomy.

Behaviour change strategy	Frequency of use
Provide instruction on how to perform the behaviour	18 studies
Provide information on consequences of behaviour in general	11 studies
Goal setting (behaviour)	11 studies
Facilitate social comparison	10 studies
Provide normative information about others' behaviour	5 studies
Prompt self-monitoring of behaviour	5 studies
Model/demonstrate the behaviour	5 studies
Prompt review of behavioural goals	5 studies

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TABLE 2 Behaviour change techniques and implementation strategies in included studies.

Reference	Behaviour change techniques	Participation rate	Maintenance
An et al. (2013)	• 1. Provide information on consequences of behaviour in general • 5. Goal setting (behaviour) • 8. Barrier identification/ problem-solving • 10. Prompt review of behavioural goals • 16. Prompt self-monitoring of behaviour • 19. Provide feedback on performance • 28. Facilitate social comparison • 29. Plan social support/ social change • 37. Motivational interviewing	• 9360 eligible individuals, 2136 (22.8%) consented online • 1698 reached per phone and assigned to study arm • 80% completed at least 4/6 web sessions and weekly check-in surveys • 80% retention rate for 7 week follow-up • 75% retention rate for 12 week follow-up	Up to 30% of individuals maintained smoking abstinence until week 12.
Correia et al. (2005)	• 5. Goal setting (behaviour) • 16. Prompt self-monitoring of behaviour • 17. Prompt self-monitoring of behavioural outcome (Monitoring of behaviour and substance intake) • 25. Agree behavioural contract	"Five of the 133 initial participants did not return for the follow-up assessment session."	Not specified
Daniel et al. (2007)	• 21. Provide instruction on how to perform the behaviour	Not specified (45 overall participants)	Not specified
Daniel et al. (2006)	• 21. Provide instruction on how to perform the behaviour	Not specified (40 overall participants)	Not specified
Everson et al. (2006)	• 21. Provide instruction on how to perform the behaviour	Not specified (37 overall participants)	Not specified
Everson et al. (2008)	• 21. Provide instruction on how to perform the behaviour	Not specified (45 overall participants)	Not specified
Faulkner et al. (2010)	• 21. Provide instruction on how to perform the behaviour	Not specified (19 overall participants)	Not specified
Fishbein et al. (2016)	• 5. Goal setting (behaviour) • 9. Set graded tasks • 15. Prompting generalization of target behaviour • 21. Provide instruction on how to perform the behaviour • 22. Model/Demonstrate the behaviour • 26. Prompt practice • 28. Facilitate social comparison • 36. Stress management. emotional control training	Baseline sample $N = 104$, but 19 drop-outs after pre-testing. Final sample $N = 85$. 15 Students in intervention group excluded as they attended <8 sessions.	Not specified
Ho et al. (2014)	• 21. Provide instruction on how to perform the behaviour	Not specified (8 overall participants)	Not specified
Blank et al. (2017); Horn et al. (2013); Horn et al. (2011)	• 1. Provide information on consequences of behaviour in general • 6. Goal setting (outcome) • 9. Set graded tasks • 16. Prompt self-monitoring of behaviour • 28. Facilitate social comparison • 35. Relapse prevention/coping planning • 36. Stress management/ emotional control training	• 40/ 60 selected schools agreed to participate, 21 schools dropped out due to time or recruitment issues. • 19 final schools, 233 participants • 3 months follow up: 75% retention rate for complete data (174/233 students) • 6 months follow up: 63% retention rate for complete data (64/233 students)	Not specified

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TABLE 2 (Continued)

Reference	Behaviour change techniques	Participation rate	Maintenance
Kerr et al. (2013)	• 1. Provide information on consequences of behaviour in general • 2. Provide information on consequences of behaviour to the individual • 4. Provide normative information about others' behaviour • 5. Goal setting (behaviour) • 21. Provide instruction on how to perform the behaviour • 22. Model/Demonstrate the behaviour • 28. Facilitate social comparison	• 1796 participants in total • 1654 participants attended ≥1 workshop • 1542 (93%) submitted 3-month data, 1512 (91%) submitted 6-month data and 1495 (90%) submitted 12-month data	"Although the PHAT program was brief, it elicited greater scores for health knowledge for at least one year after implementation." (p. 198)
Lane et al. (2012)	• 1. Provide information on consequences of behaviour in general • 2. Provide information on consequences of behaviour to the individual • 4. Provide normative information about others' behaviour (all conditions) • 5. Goal setting (behaviour) • 6. Goal setting (outcome) • 9. Set graded tasks (self-management plan) • 21. Provide instruction on how to perform behaviour (blood alcohol calculations) • 28. Facilitate social comparison	• 118 students participated in training sessions, 2 students were missing data, 13 students never presented for subsequent classes • Final sample: $N = 103$	Not specified
Melamed et al. (2022)	• 1. Provide information on consequences of behaviour in general (E-platform) • 5. Goal setting (behaviour) • 10. Prompt review of behavioural goals (coach sessions) • 36. Stress management/ emotional control training (Part of NAVIGATE)	• 192 (37.6%) eligible, 70 (36.5%) enrolled and randomized. • 21 participants in total (both intervention and control group) completed the 24-week follow up • intervention group (high intensity): 62% completed at least half of the 12 weekly calls offered, 21% completed 10 or more weekly calls	Not specified
Murphy et al. (1986)	• 16. Prompt self-monitoring of behaviour (daily journals) • 20. Provide information on where and when to perform the behaviour • 21. Provide instruction on how to perform the behaviour • 22. Model/Demonstrate the behaviour • 26. Prompt practice (meditation) • 28. Facilitate social comparison	• 60 participants eligible • 12 participants withdrew due to group assignment, 2 participants excluded due to physical conditions, 3 drop-outs during intervention phase • Follow up: 31 of 43 baseline participants	Training effect was accomplished for running group. Follow up phase: Subjects in the running condition continued running approx. 2.7 times a week, subjects in the meditation group continued meditation approx. 4.2 times a week.
Oh and Taylor (2014)	• 21. Provide instruction on how to perform the behaviour	23 participants provided complete data	Not specified
Parker et al. (2016)	• 1. Provide information on consequences of behaviour in general • 5. Goal setting (behaviour) • 6. Goal setting (outcome)	• 176 consenting participants • 60.2% (106) completed all 6 intervention sessions • Incomplete data/ drop-outs: 9.7% (17) ≤ 6 sessions due to	Not specified

(Continues)

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TABLE 2 (Continued)

Reference	Behaviour change techniques	Participation rate	Maintenance
	• 7. Action planning • 8. Barrier identification/ problem solving • 10. Prompt review of behavioural goals • 16. Prompt self-monitoring of behaviour	symptom improvement, 9.1% (16) did not commence intervention, 1.1% (2) met exclusion criteria that were not detected at baseline, 4.0% (7) withdrew due to clinical reasons and 15.9% (28) drop-outs.	
Prapavessis et al. (2014)	• 21. Provide instruction on how to perform the behaviour	$N = 30$ total sample	Not specified
Prince et al. (2020)	• 16. Prompt self-monitoring of behaviour • 19. Provide feedback on performance • 21. Provide instruction on how to perform the behaviour • 26. Prompt practice • 35. Relapse prevention/coping planning • 37. Motivational interviewing	• 46 individuals invited to participate • 9 participants withdrew • Final sample N = 37	Not specified
Rotheram-Borus et al. (2016)	• 1. Provide information on consequences of behaviour in general (informal conversations) • 5. Goal setting (behaviour) • 6. Goal setting (outcome) • 8. Barrier identification/ problem solving • 13. Provide rewards contingent on successful behaviour • 15. Prompting generalization of a target behaviour • 24. Environmental restructuring • 26. Prompt practice • 28. Facilitate social comparison • 29. Plan social support/social change • 40. Stimulate anticipation of future rewards	• Of individuals invited to participate (more than 98% of men approached agreed to participate) • 95% completed post assessment • 15% (11) men did not attend any practice • 71% attended regularly • 15% (11) men did not attend any practice	Not specified
Scott and Myers (1988)	• 5. Goal setting (behaviour) • 21. Provide instruction on how to perform the behaviour • 22. Model/Demonstrate the behaviour • 28. Facilitate social comparison	• 74 participants final sample • Complete data (pre-port) only for 36 individuals	Not specified
Stanley et al. (2017)	• 1. Provide information on consequences of behaviour in general • 4. Provide normative information about others' behaviour • 28. Facilitate social comparison	• 99% of students approached agreed to participate (18 segregated classrooms (10 female, 8 male) • 439 baseline respondents, 394 post-surveys	Not specified
Janse Van Rensburg and Taylor (2008)	• 21. Provide instruction on how to perform the behaviour	Not specified (23 overall participants)	Not specified
Taylor et al. (2006); Taylor et al. (2005)	• 21. Provide instruction on how to perform the behaviour	Not specified (15 overall participants)	Not specified
Tesler et al. (2018)	• 1. Provide information on consequences of behaviour in general • 21. Provide instruction on how to perform the behaviour • 22. Model/Demonstrate the behaviour	• 80 adolescents approached, 76 consented • Total $N = 76$	Not specified

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TABLE 2 (Continued)

Reference	Behaviour change techniques	Participation rate	Maintenance
	• 28. Facilitate social comparison		
Weinstock et al. (2014)	• 1. Provide information on consequences of behaviour in general • 2. Provide information on consequences of behaviour to the individual • 4. Provide normative information about others' behaviour • 5. Goal setting (behaviour) • 7. Action planning • 10. Prompt review of behavioural goals • 13. Provide rewards contingent on successful behaviour • 25. Agree behavioural contract • 37. Motivational interviewing	• 31 students (of 52 eligible), 8.8% of all individuals screened	"Although exercise appeared to increase across participants as a whole, there were no significant changes or differences in drinking behaviour over time or by treatment condition over time." (p. 11)
Weinstock et al. (2016)	• 5. Goal setting (behaviour) • 7. Action planning • 8. Barrier identification/ problem solving • 10. Prompt review of behavioural goals • 12. Prompt rewards contingent on effort or progress towards behaviour • 13. Provide rewards contingent on successful behaviour • 25. Agree behavioural contract • 37. Motivational interviewing	• Total of $N = 70$ participants • Completion of one MI session: 100% • Completion of two MI sessions: 91.4% • 89% of participants attended all 8 EC sessions • 60 participants completed 6-month follow up • Both conditions reported moderate to strong satisfaction	"Although participants as a whole showed a decrease in exercise frequency between 2- and 6-month follow-up, they were still exercising at greater frequency than baseline." (p. 10)
Wilson et al. (2018)	• 21. Provide instruction on how to perform the behaviour	N/a (46 overall participants of 74 interested individuals)	Not specified
(Ybarra et al., 2013)	• 1. Provide information on consequences of behaviour in general • 4. Provide normative information about others' behaviour • 29. Plan social support/social change • 35. Relapse prevention/coping planning • 36. Stress management/ emotional control training	• 585 eligible individuals, 301 approached (15% declined) • 47 participants did not complete online survey, $N = 164$ final sample • 87% retention for 4 week assessment • 80% retention rate at 3 month post quit • 5 intervention participants withdrew • Program overall accepted, text buddy intervention and program likely to be used by 50%, text Crave support used by 30%.	Maintenance significant for intervention group until 4 weeks post quit date, however not significant at 3-month post quit.

3.3 | Results of syntheses according to BCTs

Several meta-analyses were computed focusing on BCTs. To ensure comparability, only the most common clinical measures and final time points were used for calculations. Where necessary, multiple comparison groups were combined into single groups, with missing data manually computed or imputed from external sources according to Cochrane recommendations (Higgins, Thomas, et al., 2021) using Matlab, version R2021a, (www.mathworks.com, Natick, USA).

3.4 | BCTs and combined substance use outcomes

There was a significant, standardized effect of reported BCTs aiming to increase physical activity participation on combined substance use

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TABLE 3 Risk of bias assessment for included RCTs (Cochrane RoB2).

Study	Sequence generation	Allocation concealment, randomization failures	Blinding, non-protocol interventions/ analyses	Outcome assessment	Missing outcome data	Select. Outcome reporting	Other sources of bias
An et al. (2013)	L	SC	SC	L	L	SC	SC
Correia et al. (2005)	SC	SC	SC	L	L	SC	L
(Daniel et al. (2006)	SC	SC	SC	L	SC	SC	SC
Daniel et al. (2007)	L	SC	SC	SC	L	SC	L
Everson et al. (2008)	SC	SC	SC	L	L	SC	SC
Faulkner et al. (2010)	L	SC	H	L	L	L	H
Fishbein et al. (2016)	SC	SC	H	L	H	SC	SC
Ho et al. (2014)	L	SC	SC	L	SC	H	SC
Blank et al. (2017), Horn et al. (2011, 2013)	L	SC	SC	L	SC	L	L
Janse Van Rensburg et al. (2008)	SC	SC	H	L	L	SC	L
Kerr et al. (2013)	L	L	SC	L	L	SC	L
Lane et al. (2012)	SC	SC	SC	H	H	H	SC
Melamed et al. (2022)	SC	SC	SC	L	L	SC	L
Murphy et al. (1986)	SC	SC	H	H	H	H	SC
Oh & Taylor (2014)	SC	SC	H	L	H	L	L
Parker et al. (2011)	L	L	SC	L	L	SC	L
Prapavessis et al. (2014)	L	L	L	L	H	SC	H
Prince et al. (2020)	L	L	SC	H	SC	H	SC
Rotheram-Borus et al. (2016)	SC	SC	H	L	L	SC	H
Stanley et al. (2017)	SC	SC	SC	H	L	SC	H
Taylor et al. (2005, 2006)	L	SC	SC	L	L	SC	L
Weinstock et al. (2014)	H	SC	SC	L	L	SC	SC
Weinstock et al. (2016)	L	L	SC	L	L	SC	L
Wilson et al. (2018)	SC	SC	H	L	L	L	SC
Ybarra et al. (2013)	L	SC	L	SC	SC	L	SC

Note: Sequence generation: SC — Sequence generation/randomization process not specified (Correia et al., 2005; Daniel et al., 2006; Everson et al., 2008; Fishbein et al., 2016; Janse Van Rensburg & Taylor, 2008; Lane et al., 2012; Murphy et al., 1986; Oh & Taylor, 2014; Rotheram-Borus et al., 2016; Stanley et al., 2017; Wilson et al., 2018), manual allocation (Melamed et al., 2022); H — Baseline differences reported (Weinstock et al., 2014). Allocation concealment, randomization failures: SC — Not sufficiently specified (An et al., 2013; Correia et al., 2005; Daniel et al., 2006, 2007; Everson et al., 2008; Faulkner et al., 2010; Fishbein et al., 2016; Ho et al., 2014; Janse Van Rensburg & Taylor, 2008; Lane et al., 2012; Melamed et al., 2022; Murphy et al., 1986; Oh & Taylor, 2014; Rotheram-Borus et al., 2016; Stanley et al., 2017; Taylor et al., 2005; Wilson et al., 2018), randomization issues reported (Ybarra et al., 2013); H — Randomization failures and baseline differences reported (Horn et al., 2011; Weinstock et al., 2014). Blinding, non-protocol interventions/analyses: SC — Blinding unclear, no protocol for comparisons (An et al., 2013; Correia et al., 2005; Daniel et al., 2006, 2007; Everson et al., 2008; Ho et al., 2014; Horn et al., 2011; Kerr et al., 2013; Lane et al., 2012; Prince et al., 2020; Stanley et al., 2017; Taylor et al., 2005), SC — Blinding unclear, but no deviations from protocol visible (Weinstock et al., 2014; Weinstock et al., 2016), SC — Not blinded, but assessors blind to allocation (Parker et al., 2016); H — Blinding unlikely or no blinding, no protocol for comparisons (Faulkner et al., 2010; Janse Van Rensburg & Taylor, 2008; Oh & Taylor, 2014; Wilson et al., 2018), no blinding, but no deviations from protocol visible (Fishbein et al., 2016; Melamed et al., 2022; Rotheram-Borus et al., 2016), not blinded and drop-outs due to group assignment (Murphy et al., 1986). Outcome assessment: SC — Data analysis methods not stated, not stated how HR was measured (Daniel et al., 2007), some participants not randomized and included in analysis (Ybarra et al., 2013); H — Assessment likely not standardized or validated (Lane et al., 2012; Murphy et al., 1986; Prince et al., 2020), reliability or validity of outcome assessment unclear in given cultural context (Stanley et al., 2017). Missing outcome data: SC — Unclear drop-out rate, not ITT (Daniel et al., 2006; Ho et al., 2014), high levels of missing data, but ITT performed (Horn et al., 2011; Horn et al., 2013), medium drop-out rate, no ITT (Prince et al., 2020), some participants not included in ITT analyses (Ybarra et al., 2013); H — High drop-out rate, no ITT (Fishbein et al., 2016; Lane et al., 2012; Murphy et al., 1986), faulty reported drop-out rate, no ITT (Oh & Taylor, 2014). Selective outcome reporting: SC — Not all outcome data adequately reported (An et al., 2013; Fishbein et al., 2016; Janse Van Rensburg & Taylor, 2008; Melamed et al., 2022; Parker et al., 2016; Prapavessis et al., 2014; Taylor et al., 2005; Weinstock et al., 2014; Weinstock et al., 2016), adequate assessment is judged impossible (Correia et al., 2005; Daniel et al., 2006, 2007; Everson et al., 2008; Kerr et al., 2013; Rotheram-Borus et al., 2016; Stanley et al., 2017); H — Selective outcome reporting (Ho et al., 2014; Lane et al., 2012; Prince et al., 2020), no assessment possible and use of non-validated measurement tools (Murphy et al., 1986). Other resources of bias: SC — Unclear if adjustments were made for multiple comparisons (Murphy et al., 1986), bias reported in publication but not addressed how they were managed (Weinstock et al., 2014), blocked randomization in possibly unblinded study (Everson et al., 2008; Lane et al., 2012), small sample size, that was not powered to detect differences between the two groups (Ybarra et al., 2013), unclear management of study limitations (Wilson et al., 2018), unclear if adjustments performed and no descriptions of limitations (Fishbein et al., 2016; Ho et al., 2014), prospective randomized trial (Daniel et al., 2006; Prince et al., 2020). H — Improper management of study limitations (Prapavessis et al., 2014; Rotheram-Borus et al., 2016; Stanley et al., 2017), within-subject crossover design, unadjusted estimates (Faulkner et al., 2010), prospective randomized trial, clustering possibly not accounted for.

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TABLE 4 Risk of bias assessment for included NRS (non-RCTs) (Cochrane ROBINS-I).

Study	Confounding	Allocation	Intervention classification	Deviations from intended interventions	Missing outcome data	Outcome assessment	Outcome reporting	Other sources of bias
Everson et al. (2006)	L	M	L	NI	L	C	NI	L
Scott and Myers (1988)	S	M	L	NI	S	NI	S	NI
Tesler et al. (2018)	NI	S	L	NI	L	S	L	C

Note: Confounding: S = Clusters not comparable, potential confounding. Allocation: M = Allocation according to order in which participants presented (Everson et al., 2006); M = Allocation according to predefined characteristics; M = Unclear allocation (Scott & Myers, 1988); S = Students self-selected into study/intervention group (Tesler et al., 2018). Missing outcome data: S = High drop-out rate (Scott & Myers, 1988). Outcome assessment: C = Exercise intensity not measured (Everson et al., 2006); S = Subject to social desirability bias (Tesler et al., 2018). Outcome reporting: S = Only significant measures reported (Scott & Myers, 1988). Other sources of bias: S = Significant baseline differences and crossover effects, prospective study, no clear adjustments; C = Big difference in N between intervention/control group, potential conflict of interest (Tesler et al., 2018).

outcomes ($g = -0.37$, $p < .001$, 95% CI [−0.54,−0.20]), including alcohol, tobacco and illicit substance use. This finding means that the use of BCTs to promote physical activity as part of the interventions had an effect on substance use outcomes. Notably, this effect was found in interventions reporting multiple BCTs ($g = -0.33$, $p < .001$, 95% CI [−0.50,−0.16]) and interventions reporting a single BCT ($g = -1.84$, $p < .001$, 95% CI [−2.89,−0.8]) (see Figure 2). There were no interventions with nil BCTs; the lowest amount of reported BCTs in a single intervention was one. The effect was robust (by the 'one study removed' test).

Interventions using a single BCT reported a significantly larger effect than interventions that reported multiple BCTs (Q-value = 7.829, $p = .005$). However, the former subgroup also revealed a significant amount of within-group heterogeneity ($I^2 = 94.58$, $p < .001$), indicating that the large amount of variance within the observed effect of the number of reported BCTs on substance use outcomes largely derives from dispersion within the subgroup of studies that are low in reported BCTs. The variable 'number of BCTs' did not explain much of the variance within this subgroup and there may be additional moderators or confounding variables within this subgroup that explain the observed variance. The subgroup of studies that reported multiple BCTs did not show significant within-group heterogeneity among its studies ($I^2 = 38.85$, $p = .109$), suggesting minimal variation across studies in this subgroup with differences in effect explained by random sampling error. Studies with multiple BCTs were An et al. (2013); Correia et al. (2005); Lane et al. (2012); Parker et al. (2016); Rotheram-Borus et al. (2016); Tesler et al. (2018); and Weinstock et al. (2014). Studies that only reported a single BCT included Daniel et al. (2006, 2007); Everson et al. (2006); Everson et al. (2008); Faulkner et al. (2010); Ho et al. (2014); Janse Van Rensburg and Taylor (2008); Oh and Taylor (2014); Prapavessis et al. (2014); Taylor et al. (2005); and Wilson et al. (2018).

Notably, while studies high in reported BCTs generally described longer-term interventions, studies low in reported BCTs were generally short-term interventions, that is interventions of short duration (1–2 short sessions).

3.5 | BCTs and tobacco use

BCTs that promote physical activity had a significant effect of medium size ($g = -1.07$, $p = .01$, 95% CI [−1.77,−0.37]) on tobacco use outcomes. This effect was accounted for by single-BCT interventions ($g = -2.19$, $p < .001$, 95% CI [−3.46,−0.93]. These interventions were predominantly short-term, that is interventions consisting of 1–2 sessions. The subgroup of interventions that reported multiple BCTs did not have a significant effect on tobacco use outcomes ($g = -0.57$, $p = .19$, 95% CI [−1.41,0.28]). There were significant differences between the effect sizes of both groups (i.e. single BCT and multiple BCT interventions) (Q-value = 4.367, $p = .037$).

3.6 | BCTs and other outcomes

No subgroup analyses based on the number of BCTs could be computed for alcohol use outcomes (all studies in this subgroup comparison were high in reported BCTs), illicit substance use (no indication of heterogeneity) outcomes or physical activity (all studies were high in reported BCTs).

4 | DISCUSSION

This review explored the effect of BCTs aiming to increase engagement in physical activity on reducing substance use among young people aged 12–25 years at risk of problematic substance use. Interventions included trials involving light to vigorous exercise and interventions with either physically active elements or physical activity-promoting messages or education, all of which were within the scope of 'physical activity promotion' interventions.

Twenty-eight studies were included in the narrative section of the review, fourteen of which provided sufficient information to be included in the meta-analysis. A total of 27 different BCTs were identified within the interventions according to the CALO-RE taxonomy

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(Michie et al. (2011). Of these, *providing instruction on how to perform the behaviour* was the most frequently used BCT (reported in 18 studies) to increase physical activity. Other frequently reported BCTs included *providing information on consequences of behaviour in general*, *goal setting (behaviour)*, *facilitation of social comparison* and *providing information about others' behaviour*.

In addition to identifying and extracting BCTs that aim to increase physical activity, the effect of the number of reported BCTs on the post-intervention substance use and physical activity outcomes was reported to investigate the potential impact of using BCTs as part of physical activity interventions. Fourteen studies had sufficient information to be included in the meta-analysis. Analyses revealed a significant effect of BCTs on the observed pre-post behavioural differences in combined substance use outcomes (frequency of use, craving, intent of use). This effect was accounted for by interventions that reported a single BCT and interventions that reported multiple BCTs. The behaviour change technique most frequently used in interventions that were low in reported BCTs was *providing instructions on how to perform the behaviour*.

Results based on the subgroup analyses, according to reported BCTs need to be interpreted with caution (Deeks et al., 2021). Subgroups may contain different interventions (and different amounts of information) and thus have different abilities to detect effects (i.e. an effect may be detected more readily in one subgroup than another). Assumptions that a significant subgroup factor explains observed heterogeneity may therefore be premature (Deeks et al., 2021, chapter 10.11.3).

Subgroups of interventions with a single BCT (single session or short-term interventions) and interventions with multiple BCTs (longer-term interventions) demonstrated a significant effect of physical activity promotion on young people's combined substance use outcomes, with a significantly larger effect reported for single BCT, short-term interventions. These findings are consistent with previous research suggesting that the effects of behaviour change interventions may dilute over time, which is why large effects are commonly observed in short-term interventions rather than long-term interventions (Michie et al., 2009, p. 612), indicating that changes in behaviours may be difficult to maintain.

4.1 | Subcategories of substance use

Subgroup analysis according to the number of reported BCTs was only possible for tobacco use outcomes, due to significant heterogeneity in the findings for the other outcomes. Interventions reporting a single BCT showed a significant effect on the pre-post observed differences in tobacco use outcomes. In contrast, the category of interventions with multiple BCTs did not. One explanation for this is intervention duration may be a moderating factor, given that interventions with low numbers of reported BCTs were generally also short-term interventions, and interventions with high numbers of reported BCTs were mostly longer-term interventions. It is unclear if the significant effect of low numbers of BCTs in short-term interventions (measured after 1–2 brief physical activity sessions) would decrease over time (time-dilution effect). Consequently, further research exploring the maintenance of the behaviour change effect after short-term interventions is needed, as well as the potential moderating or mediating effects of intervention duration.

4.2 | Previous findings

Despite promising findings for interventions that promote physical activity among young people aged 12–25 on substance use and physical activity outcomes (Linke and Ussher (2015) Klamert et al. (2023)), implementation in practice is a challenge. Previous research shows that various challenges impede physical activity from being integrated within routine alcohol and/or other drug treatment practice (Abrantes & Blevins, 2019; Osborne et al., 2021).

We found that among the most frequently reported BCTs is *social comparison*. In previous research, social comparison has been identified as a predictor of health behaviour – such as nutritional intake and physical activity – among adolescents (Luszczynska et al., 2004; Patel et al., 2016), especially when associated with additional financial incentives. However, Arigo et al. (2020) note that social comparison may only be an effective facilitator of change under some circumstances. Underlying behaviour change theories are rarely acknowledged in intervention descriptions, and the application of social comparison as a behaviour change technique to increase physical activity often remains unclear. This is partly due to the absence of information, such as the dimensions or domains relevant for comparison, which creates confusion as to how to best apply this BCT and prevents a clear understanding of the contexts in which this BCT seems to work effectively. Arigo et al. (2020) thus propose that response variability should be investigated according to behaviour change theory and used to increase tailoring and thus the effectiveness of promoting physical activity through social comparison (Arigo et al., 2020; Gardner et al., 2010).

Compared to a review investigating the use of BCTs in physical activity interventions for adults with substance use disorder (Thal et al., 2022), our review found differences in commonly reported BCTs in the included studies. While there was an overlap in identified BCTs (*instruction on how to perform behaviour*, *goal setting (behaviour)*, *self-monitoring (behaviour)*), Thal et al. (2022) additionally highlighted *social support (unspecified)*, *behavioural practice/rehearsal*, *problem-solving* and *pharmacological support* as promising techniques for adults. Our review found *social comparison*, *providing normative information and information about behavioural consequences* and *modelling the goal behaviour* as additional commonly reported BCTs to increase physical activity behaviour. The differences in identified BCTs can be explained by the different target populations (adults versus young people), intervention type and taxonomy used (general BCT taxonomy versus taxonomy of BCTs aiming to specifically increase physical activity). For example, pharmacological support has previously been more likely to be used in adult populations and has only in recent

years moved into the research focus for younger populations (Hartmann-Boyce et al., 2018; Mann et al., 2014; Squeglia et al., 2019).

Similar to Michie et al. our review further demonstrated that both low and high levels of reported BCTs seem to have a significant effect on substance use outcomes. Dombrowski et al. (2012) have also shown in a previously conducted meta-regression that increased numbers of BCTs are not always associated with better outcomes and Arigo et al. (2020) have pointed out that BCTs may work under some circumstances but not others and thus rely on situational context, indicating that the *type* of BCT may be more critical than the *number*. Michie et al. (2009) also point out that using a larger number of BCTs, compared to a smaller number, does not automatically imply a larger effect.

The limited body of existing research on physical activity-focused interventions for young people at risk of problematic substance use is characterized by large heterogeneity. Theory-based evidence syntheses are crucial for informing and developing policy and practice. As Gardner et al. (2010) posit, research conceptualization, categorization of interventions and evaluation of intervention components according to explicit behaviour change theory could facilitate theoretical coherence in the large heterogenous body of research evidence, which in turn is critical for responsibly informing policy and practice change.

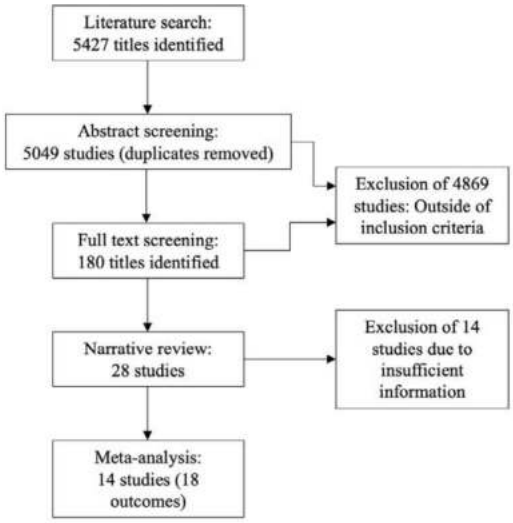

FIGURE 1 Prisma flow diagram of study selection (see also Klamert et al., 2023).

4.3 | Strengths and limitations

A strength of this systematic review is the identification and extraction of BCTs reported in interventions to increase levels of physical activity and improve substance-related outcomes use in young people.

The current study is the first, to our knowledge, to report on the effect of BCTs in the context of substance use outcomes in young people aged 12–25 years. This synthesis enables comparison across interventions, adds relevant knowledge to the existing body of evidence and can further provide meaningful directions for policy, practice change and service improvement beyond single intervention studies.

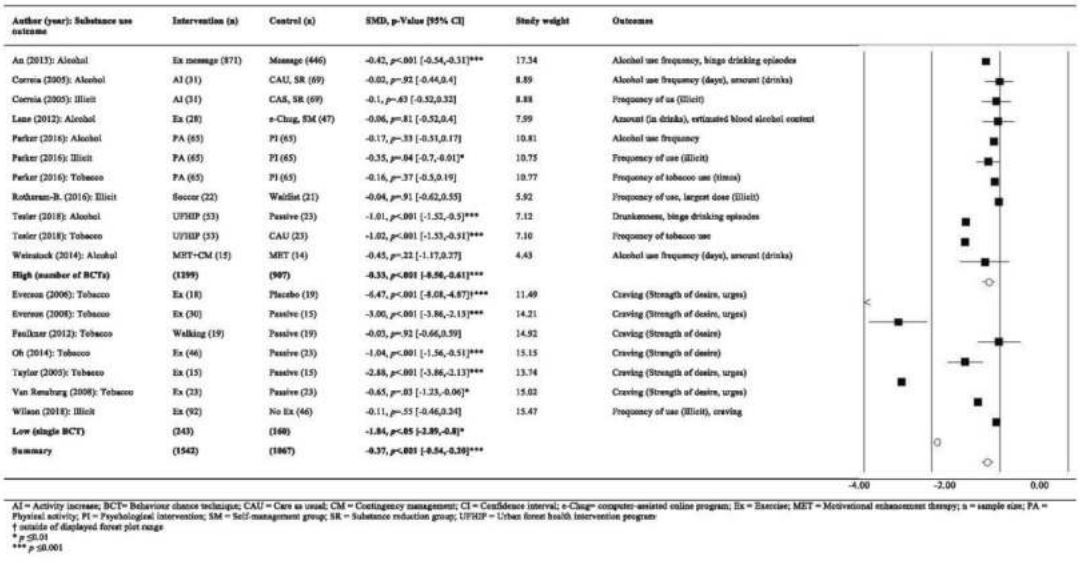

FIGURE 2 Effect of reported number of BCTs in interventions that promote physical activity on substance use outcomes.

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This review is also the first to extract BCTs in this setting based on the internationally established CALO-RE taxonomy, which provides a suitable framework to compare the findings of this review with other reviews investigating health behaviour change, such as de Bruin et al. (2009) and Jacobs-van der Bruggen et al. (2009). This taxonomy sets a scientific basis for exploring the effect of different combinations of BCTs in varied contexts to improve and increase behavioural responses in this population.

One limitation is that evidence synthesis was based on reported BCTs, which may not have captured the BCTs that were actually applied within the interventions. This highlights the importance of adequate and thorough reporting of applied BCTs as part of intervention descriptions to allow confident evidence synthesis.

Notably, this review investigates the effect of reported BCTs aiming to promote physical activity on substance use outcomes. An earlier review investigates the overall efficacy of interventions that promote physical activity (Klamert et al., 2023). To facilitate the examination of the effect of reported BCTs, different substance use outcomes were combined (frequency of use, cravings, intent to use). This poses a notable limitation to this review and is not advisable for other research questions.

Further, while analyses based on extracted BCTs explain part of the observed variance in outcomes, the heterogeneity in the established subgroups based on the number of BCTs remains significant, indicating the presence of other confounding or moderating variables which have not been identified. This may partly be explained by the general large heterogeneity in the included studies regarding intervention design, setting, outcome measures and physical activity promotion, as noted previously by Thal et al. (2022).

Last, the quality of included evidence, which had to be downgraded for several domains due to the risk of bias in the included studies, poses a limitation to the existing evidence base.

4.4 | Implications, recommendations and directions for future research

This study provides insight into commonly used BCTs in physical activity and substance use, as well as the importance of considering BCTs as part of health interventions and understanding related mechanisms of change.

Nevertheless, the circumstances under which different BCTs influence outcomes vary and remain poorly understood. Consequently, more research is recommended to investigate and apply different BCTs, targeting specific health behaviour, in various contexts. Additionally, guideline or template development for reporting BCTs delivered within behaviour change interventions is recommended to facilitate comparability among interventions, ensure high-quality evidence synthesis and strengthen policy development.

Directions for future research and important factors to include in conceptualizing and designing future studies include the long-term behavioural change effects of short-term (1–2 sessions) interventions, considering that behaviour change interventions often experience a time-dilution effect over time (Michie et al., 2009). Other recommendations for research include the investigation of the superiority of distinct combinations of BCTs, and project resources and researcher preferences associated with BCT choice.

Additionally, *knowledge translation and implementation* should be considered within this research area. Namely, effectiveness studies should include a focus on implementation in substance use and/or mental health services and educational settings, should the intervention be effective, to allow knowledge translation and implementation of effective BCTs into practice settings.

5 | CONCLUSION

Application of BCTs has a significant effect on post-intervention substance use outcomes in young people aged 12–25 years at risk of problematic substance use. While applying several BCTs within an intervention demonstrates a small, significant effect on outcomes, short-term (1–2 sessions) interventions using only single BCT demonstrated a larger effect on post-intervention substance use outcomes. These findings should be interpreted with caution. While certain combinations of BCTs may be superior to others, favourable behavioural responses to reported BCTs are likely to be context-dependent, suggesting more research is needed. The findings support the benefits of applying BCTs in interventions that promote physical activity in young people at risk of problematic substance use. Future research should improve the description of BCTs within interventions to better inform clinical decision-making and public policy.

AUTHOR CONTRIBUTIONS

Lisa Klamert conceived of the original review (search strategy, systematic search, screening phases, study selection, data extraction, RoB assessment and evidence rating, data synthesis, writing the initial manuscript). Alexandra G. Parker, Melinda Craike, Susan Kidd and Michaela C. Pascoe provided valuable guidance and input regarding the review conception, performed screening and study selection, performed data extraction and RoB assessment in duplicate and critically appraised and contributed to the manuscript. Gillinder Bedi provided guidance and critical appraisal and contribution to the original manuscript. Alexandra G. Parker, Melinda Craike, Susan Kidd, Gillinder Bedi and Michaela C. Pascoe further provided guidance, critical appraisal and contribution to the current manuscript.

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CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest regarding the content of this publication or the contributing authors. The content of this publication has not been submitted or published anywhere else.

DATA AVAILABILITY STATEMENT

All data are available upon request from the corresponding author.

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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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3.5 Underreporting of Implementation Characteristics: Publication 3

Declaration of co-authorship and co-contribution: Papers incorporated in this thesis

1. Publication details

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Name: Klamert, Lisa
Institute: Institute for Health and Sport
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2. Candidate declaration

I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

_____ _____

Signature Date

3. Co-author(s) declaration

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

1. They meet criteria for authorship in that they have participated in the conception, execution or interpretation of at least that part of the publication in their field of expertise;
2. They take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
3. There are no other authors of the publication according to these criteria;
4. Potential conflicts of interest have been disclosed to a) granting bodies, b) the editor

or publisher of journals or other publications, and c) the head of the responsible academic unit; and

5. The original data will be held for at least five years from the date indicated below and is stored at the following location(s): VU Research repository

Name(s) of co-authors	Contribution (%)	Nature of contribution	Signature	Date
Craike, Melinda	10%	Co-authorship	[redacted]	12-03-2014
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SHORT REPORT Open Access

Underreporting of implementation strategies and barriers in physical activity interventions for young people at risk of problematic substance use: a brief report

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Abstract

Background Several studies have assessed whether physical activity interventions can reduce substance use in young people at risk of problematic substance use. This report identifies and describes the reporting of implementation characteristics within published studies of physical activity interventions for young people at risk of problematic substance use and provides recommendations for future reporting.

Methods Reported implementation strategies (including intervention manualization), barriers, implementation fidelity, and personnel acceptance were extracted from studies of physical activity interventions for young people aged 12–25 years at risk of problematic substance use that were included in a previous systematic review of intervention efficacy.

Results Implementation strategies were reported in less than half of the included studies (42.9%), implementation barriers in only 10.7% of studies, intervention fidelity in 21.4%, and personnel acceptance in a single study (3.6%).

Conclusions Results indicate insufficient reporting of implementation strategies, barriers, fidelity, and personnel acceptance. Consideration of implementation characteristics is essential for implementing physical activity interventions in practice. Inadequate or limited reporting of these characteristics may contribute to delayed uptake and adoption of evidence-based interventions in clinical practice. Recommendations to improve the reporting of implementation information include integrating standards for reporting implementation characteristics into existing reporting guidelines, developing an international taxonomy of implementation strategies, and upskilling intervention researchers in the fundamentals of implementation science.

Keywords Young people, Substance use, Physical activity, Adolescents, Early intervention, Implementation

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Contributions to the literature

- The lack of reporting of essential implementation characteristics in intervention studies may limit the uptake of potentially effective physical activity interventions for young people at risk of problematic substance use into practice.
- A strong collaboration or dual skilling is essential to upskilling researchers and bridging the gap between intervention and implementation research.
- The findings of this report highlight the importance of bringing together the fields of intervention and implementation research and adequate reporting of implementation characteristics to accelerate the availability of potentially effective interventions for young people with problematic substance use.

Introduction

Adolescence and early adulthood, particularly the age group 12–25 [1], are peak periods for the emergence of psychiatric conditions and problematic substance use [2–4]. Problematic substance use and comorbid mental ill-health onsetting during this key developmental period pose critical risk factors for impaired life trajectories [2].

Physical activity (PA) and physical activity interventions represent one promising approach for early intervention for problematic substance use in young people [5, 6]. As the age range of 12–25 years is generally characterized by a decline in activity levels [7, 8], and more than 80% of young people currently do not reach recommended physical activity levels [9–11], this approach may also have benefits beyond substance use.

Early intervention and treatment are crucial to mitigate long-term consequences of substance use, mental ill-health, and sedentary behaviors in young people. Physical activity interventions have shown a beneficial effect on young people's mental and physical health including substance use behavior [5, 12]; however, they are rarely implemented into practice [13].

To improve the uptake of physical activity interventions in clinical practice, a range of factors need to be considered and addressed. One way to support the uptake of physical activity interventions into practice is to ensure that essential implementation information—including implementation strategies and barriers that have been applied or identified within trialed interventions—is routinely reported in published studies. Shortcomings in reporting of essential implementation information reduce the likelihood that these interventions will be taken up in practice if proven effective (see also Rudd et al. [14]). Reporting strategies that were used to improve implementation, or barriers encountered in the respective study settings, could be used to inform further PA implementation studies, provide useful information for decision-makers, expedite the process of uptake and implementation of effective physical activity interventions into clinical practice, and thus reduce the time from research to public health impact [14, 15]. For this reason, integrating implementation thinking and implementation strategy into intervention studies should be a research priority within both PA intervention research, but also intervention research overall. Previous research indicates that less than 50% of effective interventions are being implemented into health services, and many face decades of delays from initial evidence to their implementation [16] which leads to delays in these interventions being available to individuals [17].

Although often considered the domain of implementation trials, the entire efficacy-effectiveness-implementation research spectrum may benefit from reporting of implementation factors and integration of discrete implementation strategies. Failure to consider implementation strategies from study initiation commonly leads to unplanned mid-course corrections [16]. Integrating implementation considerations early in the research process, as part of efficacy trials, may reduce these unplanned mid-course corrections, increase intervention fidelity, streamline progression to effectiveness research and subsequent implementation [18], and accelerate an intervention's progression through the research spectrum.

To date, reviews of physical activity interventions for problematic substance use in young people have only considered the efficacy of interventions, rather than factors related to implementation. This report aimed to examine implementation strategies and barriers, implementation fidelity and acceptance of interventions among non-research personnel, and thus to highlight the importance of reporting implementation factors. The findings of this report will inform attempts to improve the reporting of intervention factors in future trials of physical activity interventions for young people at risk of problematic substance use and accelerate the uptake of evidence-based interventions into practice.

Method

A systematic review of the effects of physical activity interventions was conducted between Nov 2020–Jan 2021 and updated in Nov 2022 [5]. Study eligibility was based on the intervention of interest (physical activity interventions including multimodal and acute studies applying cognitive, behavioral, and informational approaches), population of interest (young people aged 12–25 at risk of problematic substance use, defined as

substance use that is associated with health and/or social problems and/or legal problems), outcomes of interest (substance use, physical activity, mental health), language (English), and study design (randomized-controlled trials (RCT) and non-RCT). The review included different formats and intervention approaches, including efficacy and effectiveness studies, and unimodal and multimodal approaches to provide a comprehensive review of existing evidence on physical activity interventions in this population. This report is a complimentary piece to Klamert et al. [5].

Due to the lack of international consensus regarding what comprises "critical" implementation characteristics, factors referring to implementability of healthcare interventions as reported by Klaic et al. [19] were extracted. These included implementation strategies (including sustainability and feasibility if reported), barriers (e.g., implementation context), implementation fidelity, and acceptance of the interventions among non-research personnel (for definitions see Table 1). Extracted implementation strategies were aligned with the Expert Recommendations for Implementing Change (ERIC) project, a compilation of internationally recognized implementation strategies [20]. Implementation barriers, implementation fidelity, and personnel acceptance were mapped onto the Consolidated Framework for Implementation Research (CFIR), a practical framework allowing the systematic assessment of implementation barriers and facilitators [21].

The report aimed to provide a brief overview of individual and service level factors associated with the implementability of healthcare interventions to highlight existing shortcomings, and the need for advancements in reporting standards relating to physical activity interventions for young people with substance use.

Results

Twenty-eight studies were included in the review. Most of the interventions (92.9%) were delivered in educational or community settings. One or more implementation strategies were reported in 42.9% of the included studies (12/28), while 10.7% of the studies (3/28) reported one or more implementation barriers, 21.4% of studies reported on implementation fidelity (6/28), and 3.6% of studies (1/28) reported on acceptance of the intervention among involved non-research personnel.

Ninety-four percent of the extracted implementation strategies could be mapped onto 16 strategies included in the ERIC project. Fifty-seven implementation strategies included under the ERIC framework were not reported in any included study. The most frequently reported ERIC implementation strategies were *conduct ongoing training* (for peers, coaches, and staff) (25%, 7/28 studies) and *change service sites* (change service location to increase access) (14.3%, 4/28 studies). Five studies (17.9%) reported the development of manuals (i.e., *develop education materials* according to ERIC) based on the intervention or intervention elements. Two extracted strategies could not be assigned to ERIC implementation strategies (i.e., division of facilitation workload across multiple individuals to minimize facilitation burden).

Only four studies (14.3%) assessed implementation barriers and facilitators in line with proposed CFIR constructs, which are thought to be essential to the successful implementation of interventions. The most frequently assessed barriers were *location conditions* (Outer setting domain, assessed by 7.1%, 2/28 studies). Other barriers assessed included *local attitudes* (3.6%, 1/28 studies), *critical incidents* (3.6%, 1/28 studies), and *innovation deliverers* (3.6%, 1/28 studies). Implementation facilitators (personnel acceptance) were only reported in one included study. Forty-two essential implementation constructs according to the CFIR were not assessed in any study. For detailed implementation characteristics and their mapping onto ERIC and the CFIR, see Supplementary Table 1. For the pattern of reported implementation characteristics, see Table 2.

Discussion

This report outlines the reporting of implementation factors, including strategies, barriers, fidelity, and personnel acceptance, within studies of physical activity interventions for young people at heightened risk of problematic

Table 1 Definitions of extracted implementation characteristics

Implementation characteristic	Definition
Implementation strategies	Arrangements of techniques that aim to enhance the adoption, implementation, and maintenance of clinical interventions and/or practice [15, 22] and facilitate change within the institutions or organizations in which interventions are implemented [23]
Implementation barriers	Factors obstructing the implementation of interventions [24]
Implementation fidelity	The degree to which an intervention is delivered as intended. High implementation fidelity is critical to the successful translation of evidence-based interventions into practice ([25], p. 1)
Personnel acceptance	Acceptance, intervention-knowledge, attitudes towards or adherence to the intervention among facilitating non-research personnel (i.e., providers) [26]; the extent to which an intervention is being perceived as agreeable, palatable by facilitators [27]

Table 2 Reporting of implementation characteristics of physical activity interventions for young people at risk for problematic substance use

Reference	Implementation strategies	Implementation barriers	Manualized	Implementation fidelity	Personnel acceptance
An et al. [28]	✓	X	X	X	X
Correia et al. [29]	X	X	X	X	X
Daniel et al. [30]	X	X	X	X	X
Daniel et al. [31]	X	X	X	X	X
Everson et al. [32]	X	X	X	X	X
Everson et al. [33]	X	X	X	X	X
Faulkner et al. [34]	X	X	X	X	X
Fishbein et al. [35]	✓	✓	✓	X	X
Ho et al. [36]	X	X	X	X	X
Blank et al. [37], Horn et al. [38], Horn et al. [39]	✓	X	✓	X	X
Janse Van Rensburg and Taylor [40]	X	X	X	X	X
Kerr et al. [41]	✓	X	✓	✓	X
Lane et al. [42]	X	X	✓	X	X
Melamed et al. [43]	✓	X	X	✓	X
Murphy et al. [44]	X	X	X	X	X
Oh and Taylor [45]	X	X	X	X	X
Parker et al. [46]	✓	X	✓	✓	X
Prapavessis et al. [47]	X	X	X	X	X
Prince et al. [48]	✓	X	X	X	X
Rotheram-Borus et al. [49]	✓	✓	X	✓	X
Scott and Myers [50]	X	X	X	X	X
Stanley et al. [51]	✓	✓	X	X	X
Taylor et al. [52], Taylor et al. [53]	X	X	X	X	X
Tesler et al. [54]	✓	X	X	X	X
Weinstock et al. [55]	X	X	X	X	X
Wilson et al. [56]	X	X	X	X	X
Weinstock et al. [57]	✓	X	X	✓	✓
Ybarra et al. [58]	✓	X	X	✓	X

substance use. Extracted implementation factors were mapped onto existing implementation-focused systems and frameworks (ERIC, CFIR). Based on an efficacy-effectiveness review conducted by Klamert et al. [5], the reported implementation factors were extracted from 28 included studies. The review found that ERIC implementation strategies were under-reported as part of PA interventions; less than half of the identified studies reported implementation strategies that were used as part of the interventions. Implementation knowledge, which is essential to the successful implementation of an intervention according to the CFIR framework, such as implementation barriers, was only reported by just over a 10th of included studies. Implementation fidelity was reported by roughly one quarter. While the investigated studies included PA intervention studies only, findings of under-reporting may apply to other types of interventions more broadly, as indicated by an ongoing separation (rather than integration) of intervention development and implementation knowledge in healthcare research.

There was an overlap in extracted strategies with previous findings reported within the implementation of health interventions. This overlap included ongoing training courses in intervention delivery [59, 60], the use of train-the-trainer strategies, and accessing new funding [20, 59, 60]. Additional implementation strategies—not employed in studies covered in this review—have been identified in the literature more broadly [20].

Reported implementation barriers in this report aligned with those identified by Langley et al. [61] and Josyula and Lyle [62], namely, local conditions and attitudes (e.g., cultural environment) and increased workload on clinicians and administration as barriers (CFIR constructs: implementation team members, work infrastructure).

With reporting on personnel or provider acceptance limited to a single study, it was not possible to

meaningfully compare findings with previous research evidence. Overall, personnel acceptance of and attitudes toward the implementation of evidence-based interventions have not been well studied within the international context [63].

Poor reporting of implementation strategies as part of research studies reduces the chances of evidence-based interventions being taken up into routine care and limits conclusions that can be drawn by decision-makers regarding the trialed interventions [16, 22].

One factor contributing to underreporting of implementation as part of intervention descriptions, but also impeding a priori integration of implementation considerations, is the inconsistent use of implementation terminology, even within the field of implementation science [64]. Consensus building and standardization of terms are essential to streamlining communication in these emerging fields [65, 66] and to the dissemination of implementation knowledge in research and practice [65]. Several attempts to develop international taxonomies of published implementation strategies [20, 67, 68], measure the effectiveness of individual strategies [69], and assess tailored implementation strategies for different contexts have been undertaken [20]. However, implementation strategies must not be just reported, but also "adequately reported," i.e., reported in sufficient detail to allow for measurement and reproducibility of the strategy and/or its components in research or practice [22], to be useful and allow real-world application [70, 71].

Another factor contributing to poor reporting of implementation strategies may be the limited training of researchers studying new interventions in implementation science and the lack of direct consultation or collaboration of research teams investigating new health interventions with skilled implementation researchers (see also [72]). Proctor et al. [72] argue that this is due to the emerging nature of the field of implementation science, which continues to struggle with conceptual and methodological challenges.

Limitations

There are several limitations to this report. Studies included were predominantly set in educational or community settings. For this reason, it is unclear whether the information extracted can be generalized to clinical settings.

Further, based on the shortcomings in reporting implementation characteristics in included studies, resulting in the extraction of only a small number of implementation characteristics, authors were not able to draw any conclusions regarding the effectiveness of reported implementation strategies and their impact on intervention success. Additionally, the authors' decision to focus on a framework relating to the implementability may entail the exclusion of other implementation characteristics that are seen as relevant by other members of the scientific community.

Recommendations

Based on current and previous evidence of underreporting of implementation characteristics in physical activity interventions for young people at risk of problematic substance use, we suggest the following recommendations for future research on PA interventions, but also healthcare interventions more broadly:

1. Upskill intervention researchers in the field of implementation. This could increase the likelihood of implementation considerations being included in the early stages of intervention development. A priori considerations in the early stages of research regarding the streamlining of evidence-based interventions from efficacy testing to implementation would likely lead to faster availability of effective interventions to clients.
2. Strengthen linkages between the fields of intervention research and implementation science through strong networks and multidisciplinary teams. While implementation science has developed from a need for effective interventions and treatments to be streamlined to clinical practice, both fields operate mostly independently with neither benefiting from discoveries in the respective other field in a timely manner.
3. Establish collaborations with and recruiting health care practitioners and relevant personnel (i.e., intervention facilitators) as research team members ([73], see also [74]).
4. Integrate existing taxonomies of implementation strategies subject to international consensus to decrease inconsistent terminology within the fields of implementation science.
5. Integrate reporting guidelines (including strategies, barriers, fidelity) (see also [22, 75]) into existing, internationally recognized reporting guidelines and checklists, such as the Template for intervention description and replication checklist (TIDieR) [13].
6. Establish implementation strategy as a research priority rather than a research addition or extension in the field of intervention development.

Conclusion

There is limited reporting of implementation characteristics (including implementation strategies, barriers, intervention fidelity, and acceptance of interventions among non-research personnel) in studies of physical

activity interventions for young people at heightened risk of problematic substance use. The underreporting may be related to several issues, including inconsistent implementation terminology, limited (a priori) integration of implementation considerations in intervention development, a limited number of researchers who are skilled in both implementation science and intervention development, and the absence of reporting standards for implementation characteristics. Exploration of these issues may reduce the underreporting of implementation characteristics in future publications.

Several recommendations to reduce underreporting and increase consideration of implementation characteristics as part of PA intervention research, but also healthcare intervention research overall have been made, including the development of internationally recognized standards for the reporting of implementation characteristics. Increased, high-quality reporting of this information is one factor that will likely contribute towards increasing the uptake of effective physical activity interventions in practice and streamlining intervention development from efficacy testing to implementation.

Abbreviation
PA Physical activity

Supplementary Information

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Additional file 1: Supplementary Table 1. Detailed implementation characteristics of included studies.

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Authors' contributions
LK conceived of the review; designed the search strategy; completed the systematic search, screening phases, study selection, data extraction, bias assessment, and data synthesis; and wrote the initial manuscript. AP, MC, SK, and MP provided valuable guidance and input regarding the review conceptualization and performed screening, study selection, data extraction, and bias assessment in duplicate. AP, MC, GB, and SK provided guidance, critical appraisal, and expertise to this manuscript. All authors reviewed and approved the final manuscript.

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3.6 Discussion

3.6.1 Review highlights

The systematic review, reported across the three publications above, demonstrated several potential health benefits of physical activity interventions for young people aged 12-25 years at risk for problematic substance including improvements in substance use outcomes (e.g., reduction in cravings), improvements in mental health and increased participation in PA. Additionally, the review indicated that a focus on behaviour change techniques as part of these interventions may have an additional effect on substance use reduction. It further highlighted the importance of considering and reporting essential implementation characteristics as part of intervention studies to support the translation of effective interventions into practice and reduce research waste.

In Publication 1 just under two thirds (61%) of the included short-term and long-term interventions (n=28 studies) improved substance use outcomes in young people, namely frequency and amount of alcohol, tobacco, and illicit substance use, as well as associated outcomes, such as reduced cravings. Intervention effects were reported for unimodal and multimodal studies, as well as a range of different intervention formats, including varying intervention duration and delivery format. However, due to the low quality of the existing evidence, findings had to be interpreted with caution.

Publication 2 reported a significant effect of reported BCTs, which aimed to improve physical activity participation, on observed pre-post substance use outcomes in young people. While studies reporting a higher number of BCTs and studies reporting the application of a single BCT reported an effect, the demonstrated effect was significantly larger for the latter group. Findings overall supported the application of BCTs in PA interventions, yet also highlighted the need for further research.

Lastly, publication 3 revealed that there is limited reporting of essential implementation characteristics as part of the investigated studies, which may impede the adoption of effective interventions into practice. Several recommendations were made to improve reporting of implementation characteristics, including the development of international reporting standards in this area.

There were several shortcomings in the existing research evidence that were identified as part of the review, which shaped how findings can be interpreted and how much weight they carry. These concerns are discussed in chapter *3.6.3 Limitations of Phase 1*.

Nevertheless, the identified potential benefits of PA interventions for early intervention and substance use reduction in young people as well as high levels of physical inactivity in this at-risk population, stimulates the question of why little consideration is given to the integration of physical activity into best practice models of clinical treatment.

Further, several of the effective interventions included in this review were characterised by highly tailored physical activity interventions (An et al., 2013; Parker et al., 2016; Ybarra, Holtrop, Prescott, Rahbar, & Strong, 2013). This calls attention to the importance of young people's unique characteristics, motivations, experiences, and needs in designing PA interventions that are appropriate for them. Further, the emphasis on tailored and personalised interventions provides meaning and context to the research described later in this thesis, which focuses on young people's unique preferences, experiences, and needs (see *Chapter 4. Young People's Expertise: A Mixed Methods Exploration*).

3.6.2 Interpretation of Phase 1 findings within the CFIR

The Consolidated Framework for Implementation research has been recommended as a guiding framework for investigating which interventions work within the existing substance use treatment practice and for exploring underlying factors that contribute to the demonstrated effects (Damschroder & Hagedorn, 2011). According to the framework, successful implementation is influenced by the perception of the five framework dimensions (*innovation*, *outer setting*, *inner setting*, *individuals* involved and the *implementation process*) by various relevant stakeholders, i.e. organisations, intervention facilitators (e.g., clinicians, coaches, teachers, peers) and affected young people (Damschroder et al., 2022).

Chapter 3 addressed several domains of the CFIR, including the innovation (i.e., intervention) characteristics, the outer and inner settings of interventions and the implementation process. For the domain 'innovation characteristics', Publication 1 provided an overview of existing interventions and their characteristics, highlighting the potential of varying intervention formats such as long-and short-term interventions to reduce substance use, and provided a description of effective interventions. As such, Publication 1 provided insight into constructs such as *intervention source*, *evidence strength and quality*, and *cost* (reported in some studies only). For instance, one study reported embedding the trialled intervention into FIFA's (Federation Internationale de Football Association) steady and sustainable funding stream to ensure that the intervention can continue beyond the trial (Rotheram-Borus et al., 2016). Further, some interventions reported on the construct of patient needs and resources in

the CFIR domain *outer setting*. Last, in the CFIR domain *implementation process*, the constructs *execution of interventions* (including intervention fidelity) was addressed by three interventions.

Publication 3 highlighted the limited reporting on all relevant implementation domains, as suggested by the CFIR. For instance, there was notable underreporting of essential intervention characteristics, implementation strategies and barriers, acceptability, and intervention fidelity (contributing to the CFIR domains 'innovation', 'inner setting' and 'implementation process'). Publication 2 addressed elements of the "implementation process" domains.

While Phase 1 (Chapter 3) provided some insight into what has worked for effective interventions on some of the domains that are essential to successful implementation, it also called attention to the lack of consideration of most domains as part of intervention development and testing. Poor reporting of factors that are essential to successful implementation of interventions contributes to delayed uptake of effective interventions into practice; consideration of the CFIR framework and its domains as part of efficacy and effectiveness testing is therefore recommended. The CFIR domains *individuals* (including constructs such as *need*, *capability*, o*pportunity* and *motivation* are addressed in chapter *4.6.2 Strategic alignment of service needs, barriers/benefits to PA onto COM-B and CFIR*.

3.6.3 Limitations of Phase 1

Several areas for improvement were identified which are essential to interpreting the magnitude of the findings. Firstly, the included studies were predominantly set in Western, industrialised countries. While this likely allows generalisation of findings to Australia, it does not acknowledge developing countries, which largely accounted for the rising trend in legal and illicit substance use among young people in recent years (United Nations Department of Economics and Social Affairs, 2019).

Secondly, while physical activity may provide a less stigmatising, early intervention approach, as well as address some of the existing treatment challenges in young people with problematic substance use (e.g., low motivation, high attrition), these outcomes were not measured in any of the included studies. Thus, no clear inferences can be drawn.

Thirdly, the low-quality reporting and the heterogeneous nature of the existing research evidence, namely the variety of different substances assessed, limit the comparability of studies

and reduce the certainty of and confidence in the current evidence. No clear inferences can be drawn regarding the effect of PA interventions for substance types other than tobacco use.

3.7 Chapter Summary

This chapter critically appraised and synthesised the existing evidence on the effect of PA interventions for young people aged 12-25 years who are at risk for problematic substance use. Publication 1 described the intervention effect on substance use outcomes in young people and provided an overview of different intervention formats, including long-term and short-term interventions, and their potential impact on substance use treatment practice. The second publication explored the meaning of the effect within a behaviour change context by describing behaviour change techniques that were reported as part of the identified interventions and their effect on substance use outcomes in young people. The third and last publication reported on the issue of underreporting of implementation characteristics as part of the investigated interventions; implementation knowledge that may be essential to the translation of effective interventions into practice if it were reported. Chapter 3 overall provided promising evidence on the beneficial effect of the described interventions on substance use outcomes in young people; however, it highlighted several crucial shortcomings in the evidence, which need to be considered when interpreting the effects and translating into practice.

The following *Chapter 4. Young People's Expertise: A Mixed Methods Exploration* examines correlates of the acceptability of PA interventions in young people, as well as young people's perspectives, insights, experienced barriers and needs regarding the integration of PA interventions into substance use treatment practice.

PHASE 2- YOUNG PEOPLE'S EXPERTISE

4 Young People's Expertise: A Mixed Methods Exploration

4.1 Chapter Introduction

This describes Phase 2 of the research project, which investigated the correlates of intervention acceptability in young people, i.e. which factors influence how acceptable physical activity interventions are to young people, and describes preferences, needs and experienced barriers regarding PA interventions as reported by young people. The chapter further highlights the importance of integrating young people's insights into research and inviting them as research partners rather than just research participants.

Young people's acceptability of PA interventions and their perspectives and insights are explored using a mixed methods approach. First, correlates of acceptability, experienced barriers to physical activity and demographic characteristics are described using data collected via a quantitative online survey. As a second step, in-depth insights into young people's preferences, experienced barriers and perceived service needs are explored qualitatively using a focus group applying creative methods.

The chapter concludes by drawing together quantitative and qualitative findings and integrating these in a mixed-methods discussion to provide a meaningful context for the integration of PA interventions into substance use treatment practice for young people. Together with Phase 1, this chapter (Phase 2) informs the practice and research recommendations described in Phase 3.

4.2 Aims and Objectives

Phase 2 aimed to investigate the acceptability of physical activity interventions in young people with problematic substance use, explore moderating factors of acceptability and young people's preferences, as well as the perceived barriers to PA participation and PA interventions. It was guided by the research sub-question "What factors contribute to the acceptability of physical activity interventions in young people with problematic substance use, and what are

young people's preferences, insights and barriers regarding the integration of PA interventions into substance use treatment practice (RQ2)?" (see chapter *1.5 Research Aims and Objectives*).

Phase 2 used a mixed methods approach, with quantitative, qualitative, and mixed methods research addressing complementary research aims:

1. Quantitative research aims: Assess young peoples' reported acceptability of PA interventions, levels of PA participation, mental health, substance use and experienced PA barriers to identify correlates of treatment acceptability, i.e. which factors increase or decrease acceptability of PA interventions.
2. Qualitative research aims: Gain a deeper understanding of young people's perceived barriers to PA participation and PA interventions through a qualitative focus group and inquiring about young people's preferences and service needs.
3. Mixed methods research aim: Discuss and compare the quantitative and qualitative research findings and integrate them meaningfully to guide practice and future research.

4.3 Mixed Methods Design

Mixed methods designs describe "*the use of two (or more) research methods in a single study, when one (or more) of the methods is not complete itself*" (Morse & Niehaus, 2009, p. 9). Mixed methods imply "the incorporation of one or more methodological strategies […] into a single research study, in order to access some part of the phenomenon of interest that cannot be assessed by using *the first method alone*" (Morse & Niehaus, 2009, p. 9).

A sequential explanatory research approach was used to investigate the phenomenon of interest, namely young people's perspectives on integrating PA interventions into substance use treatment. Quantitative data was collected as a first step, followed by the subsequent collection of qualitative data to elaborate on and explain the previously collected data in more depth (Ivankova, Creswell, & Stick, 2006). The mixed methods approach enables a more detailed exploration of complex questions, such as those explored in this study, than just one method alone (Creswell, 2003). The overall inquiry approach to Phase 2 was descriptive and interpretative. It allowed an exploration of young people's experiences on multiple levels, including a macro (i.e., groups) and micro (i.e., individuals) level (Ivankova et al., 2006). Deductive reasoning was applied in the quantitative study and an inductive inquiry was applied in the qualitative study to generate new ideas about integrating PA interventions into treatment practice.

The mixed methods approach was chosen to examine the complexity and sensitive nature of young people's experiences (Earnshaw et al., 2019), to recognise young people as experts in their own experiences (Richardson, 2020), to provide a meaningful context for quantitative data and to explore interventions that are appropriate to address young people's needs by directly integrating young people's knowledge (Blanchard & Fava, 2017; Orygen, 2019).

4.3.1 Quantitative survey

The research approach commenced with an online research survey. Young people were screened according to their age, substance use and their willingness to engage with clinical services. This ensured that only young people aged 16-25 who reported problematic substance use and would be willing to engage with services such as PA interventions completed the survey. Responses to the survey were anonymous. The survey included several reliable and valid questionnaires which assessed young people's substance use (WHO ASSIST; WHO, 2010a) , their sociodemographic background, their PA participation (Active Australia Survey; AIHW, 2003) , perceived benefits and experienced barriers to PA (EBBS; Sechrist, Walker, & Pender, 1987), psychological distress (K10; Kessler et al., 2002), and how acceptable they perceive PA interventions to be (TAP; Sidani, Epstein, Bootzin, Moritz, & Miranda, 2009). Additionally, young people were invited to express their interest in participating in a subsequent qualitative focus group to assess their perspectives regarding PA interventions in more detail. Only young people who indicated they were 18 years or older were invited to nominate themselves for the focus group. For a detailed list of survey questions, see Appendix B.3.

4.3.2 Qualitative focus group

Young people who completed the research survey were invited to participate in a subsequent 2-hour online focus group. Young people aged 18 and above could participate in the focus groups. No additional screening procedures were conducted, as young people had already been screened for eligibility during the previous stage.

The focus group followed a semi-structured format. A pre-determined set of questions were used to prompt engagement and discussion among the participants, with the facilitator able to explore answers in more detail as required. The pre-determined questions built upon data acquired during the previous quantitative research and aimed to explore some of these themes in more depth. The focus group was facilitated with the help of the Miro platform, an

online whiteboard technology highly suitable for creative collaboration (https://miro.com/online-whiteboard/). Participants were invited into a respectful and inclusive dialogue, including creative brainstorming activities to enhance communication (Hagen & Rowland, 2011). Focus groups are recommended as an appropriate, participatory method for young people (Australian Government Department of Health, 2004; Hagen & Rowland, 2011).

4.3.3 Interpretative discussion

The quantitative and qualitative phases were integrated (or mixed) at several stages throughout Phase 2. The sequential design assisted in linking the two phases, which enabled the recruitment of quantitative participants (survey) for the qualitative phase (focus group). The quantitative and qualitative findings were "mixed" (i.e., integrated) during the interpretation and reporting stage by jointly displaying findings, highlighting the similarities and differences. No data mixing using data transformation was performed (e.g., transformation of qualitative data into quantitative counts) due to the size difference between the two datasets (Fetters, Curry, & Creswell, 2013).

Table 2

Different stages of the applied mixed methods approach

	Quantitative	Qualitative	Mixed-Methods
Eligibility	Aged 16-25 years Current problematic substance use Willing to engage with clinical services	Aged 18-25 years Current problematic substance use Willing to engage with clinical services	Data from previous stages
Data type	Numeric data	Narrative/verbal data	Integrated numeric/narrative data from previous stages
Data source	Research survey	Focus group	Integrated previous stages
Data analysis	Statistical analysis	Content analysis	Interpretative discussion
Collected data	Substance use Sociodemographic information PA participation Perceived benefits to PA Experienced barriers to PA Mental health Acceptability of PA interventions	Previous experiences PA intervention benefits PA intervention barriers Service needs (PA interventions) Preferences (PA interventions)	Integration of data from previous stages

4.4 Quantitative Research Survey

4.4.1 Method

The research survey investigated the acceptability of physical activity interventions among young people aged 16-25 years with problematic substance use, as well as other related factors, such as their mental health. The individual objectives of the quantitative data collection were to:

(a) Explore treatment acceptability of physical activity among young people aged 16-25 with problematic substance use;
(b) Investigate differences in treatment acceptability according to gender, experienced barriers or substance use;
(c) Uncover variables that may contribute to treatment acceptability, such as mental health, physical activity participation and substance use;
(d) Explore the current substance use patterns and participation in PA; and
(e) Describe experienced barriers to physical activity, mental health states and interactions between these variables of interest.

4.4.1.1 Online survey: Sample and eligibility

The sample included young people aged 16-25 years with problematic levels of substance use, who were recruited through Victoria University student services and digital social media community platforms, such as Facebook community groups, between July 2022 and September 2022. For social media and online platforms, a survey flyer detailing essential information in brief (e.g. eligibility criteria) was posted in several Facebook community groups and social media groups with a known, heightened risk of substance use (e.g., online skateboarding groups). Additionally, the survey invitation was distributed three times via e-mail to all students by Victoria University Student Services. A sample size of 50-100 individuals was judged to achieve the relevant power requirements for regression and correlation analyses of the survey data (Wilson VanVoorhis & Morgan, 2007). Any young people between the ages of 16-25 years, including "mature minors" aged 16-18 years able to consent without parental supervision (see 4.4.1.2. for the Australian concept of mature minor), engaged in problematic substance use and willing to engage with health services were eligible to participate. "Problematic substance use" was defined as being at moderate or severe risk of experiencing substance-related health issues as assessed by the WHO *Alcohol, Smoking, and Substance*

Involvement Screening Test (ASSIST). For a detailed definition of problematic substance use in young people in the context of this study see chapter 1.2.2. Substance use.

4.4.1.2 The research survey

The research survey consisted of several reliable and valid measures which assessed treatment acceptability of PA intervention among young people, PA participation, mental health, substance use and perceived benefits and barriers to physical activity. Additionally, the survey included study information and a consent form (Appendix B.1, B.2), a list of Victorian support sources, screening measures, questions on sociodemographic data, and a measure of nicotine dependence. The survey was constructed and delivered using the online experience management software Qualtrics, version May 2023 (SAP, Seattle, United States). A complete list of measures and their descriptions can be found in Table 3.

Two additional questions ("consent check") were added to the consent information to investigate underage participants' capacity to voluntarily consent according to the *Australian concept of a mature minor* (Friedman et al., 2016; Mackenzie, Berger, Holmes, & Walker, 2020). The consent check ensured that participants, particularly those aged 16-18 years, understood the context of their participation, and provided consent voluntarily.

The primary outcome of interest in the quantitative study was the treatment acceptability of physical activity interventions, which was assessed with the *Treatment Acceptability and Preferences Scale* (TAP; Sidani et al., 2009). The TAP aims to evaluate overall treatment acceptability based on four treatment attributes: Suitability, appropriateness, effectiveness, and willingness to adhere. Appropriateness refers to the perceived ability of the treatment to address the presenting problem (e.g., problematic substance use), suitability to the congruence between treatment and lifestyle, and effectiveness to the treatment's perceived ability to manage or change the presenting problem (Miranda, 2004). Each item is rated on a 4-point Likert scale. A treatment is perceived as "acceptable" if it appears effective, appropriate, easy to apply and congruent with a person's lifestyle (Tarrier, Liversidge, & Gregg, 2006). The scale has been applied to measure treatment acceptability of PA interventions in the past (Fox, Sidani, Brooks, & McCague, 2018; Fox, Sidani, Zaheer, & Butler, 2022).

Table 3

Survey elements and descriptions of the quantitative research survey

Survey element	Description
1. Study information	Study information on the background, purpose, renumeration, potential risk and benefits of the conducted study.
2. Informed consent	Informed consent form to assess participants' name, age and consent.
3. List of Victorian support resources	Victorian support resources to mitigate the risk of discomfort during survey participation. These included: Lifeline Australia, Beyond Blue, Counselling Online, Headspace, Kids Helpline, National Alcohol and Other Drug Hotline, DirectLine.
4. Screening question on age	Screening question to assess participant's age eligibility
5. The Alcohol, Smoking and Substance Involvement Screening Test (WHO ASSIST, version 3)	An international screening tool developed to assist with early identification of substance use related risks of the following substance groups: Alcohol, tobacco products, cannabis, cocaine, amphetamine-type stimulants, inhalants, sedatives, hallucinogens, opioids, and other substances. The ASSIST collects information on several substance related behaviours including intoxication, withdrawal symptoms, regular use and injecting use. Sum scores are categorised according to three risk categories of experiencing substance related health or other problems: low risk, moderate risk, high risk (dependence) (World Health Organization, 2010a).
6. Screening question on openness/willingness to engage with clinical services	Screening question to assess participant's willingness to engage with substance use specific health services (as indicated by past engagement or openness to engage in the future)
7. Fagerström Test for Nicotine Dependence (FTND)	Screening tool to assess intensity of addiction to nicotine by exploring cigarette consumption, compulsion to smoke and dependence (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991).
8. The Kessler Psychological Distress Scale (K10)	Global mental health measure assessing psychological distress based using a 10-question screening scale. Higher scores indicate increased psychological distress; sum-scores are categorised according to 4 categories: psychologically well, mild psychological distress, moderate psychological distress, severe psychological distress likely indicating severe mental illness. The scale can be separated into 2 subscales: anxiety and depression subscales (Kessler, Andrews, Colpe, Hiripi, Mroczek, Normand, et al., 2002).

Survey element	Description
9. The Active Australia Survey (AAS)	Australian measure investigating participation in leisure-time physical activity in times and minutes/hours per week. The assessed physical activities include continuous walking, heavy yard work, and engagement in moderate and vigorous physical activity (Australian Institute of Health and Welfare, 2003).
10. Strength items of National Health Survey	An Australia-wide health survey conducted by the Australian Bureau of Statistics, which collects information on long-term health conditions, demographic and socioeconomic information and health behaviour including physical activity. The included strength items assess participation in activities designed to increase muscle strength or toning such as weight lifting (Australian Bureau of Statistics, 2018a).
11. Treatment Acceptability and Preference Questionnaire (TAP)	Measure to assess participant's perceived efficacy, acceptability, suitability of a described treatment on a 5-point-likert scale. The TAP further assesses participant's willingness to engage in the described treatment. Scores can be summed by calculating the mean of all scales to derive an overall measure of treatment acceptability (Sidani et al., 2009).
12. Exercise benefits/Barriers Scale (EBBS)	A 43-item measure collecting information on perceived benefits of and barriers to exercise. Likert-scores can be summed to provide a total score or can be separated into individual benefits and barriers scales (Sechrist et al., 1987). For the purpose of this study five additional items were added to the EBBS, including items assessing exercise in relation to substance use, motivation, and access to exercise equipment. Total scores indicate increased/decreased perception of benefits and barriers.
13. Opt-in option	Opt-in option inviting participants to express their interest to participate in a subsequently conducted focus group interview.

Skip-logic, i.e., programmed guidance of research participants through the survey based on their responses, was used to guide and filter out ineligible participants. A built-in opt-in option at the end of the survey allowed participants aged 18 and older to express their interest in participating in the subsequent focus group.

4.4.1.3 Computer programs, software and packages

Both *IBM SPSS Statistics* and *R programming language* were used to explore the data. For SPSS, version 29.0.0.0 (IBM, New York, United States) (for Mac) was used for data preparation and cleaning, data corrections and manipulations and simple data explorations. R, version R 4.2.1 (GUI 1.79 High Sierra build, R Foundation for Statistical Computing, Vienna, Austria) was used, as well as RStudio (version 2022.12.0, Posit PBC, Boston, United States) for non-parametric modelling, including decision (regression) tree modelling, data mining and generalised additive models. Data mining refers to analytical approaches aiming to uncover latent patterns and maximise knowledge extraction from large datasets (Sumathi & Sivanandam, 2006). For R packages that were used for data exploration and analysis see Appendix B.4.

4.4.2 Data preparation

Several steps were performed before conducting data analysis, including data preparation and organisation, data checking and cleaning, testing of assumptions (e.g., normal distribution), and analysis of outliers. Quantitative coding of the available data, i.e. assigning numeric values to responses, was predominantly facilitated by Qualtrics (version May 2023; Seattle, US) as part of survey construction.

First, data checking, re-organisation of data and relabelling and label adjustments of variables were performed in Excel (Version 16.72), which is recommended for data manipulation before conducting statistical analyses (Goldwater, 2007). As a second step, all data were transferred to IBM SPSS Statistics software (version 29.0). Further, sum values were calculated and included as individual variables for several measurement tools. Due to their Likert-based response scheme, individual items of included scores were defined as categorical (i.e., ordinal) variables. However, the sum scores of questionnaires were defined as quantitative (scale) variables (Bernstein, 2005; Carifio & Perla, 2008; Joshi, Kale, Chandel, & Pal, 2015; Sullivan & Artino, 2013).

4.4.2.1 Errors in categorical and quantitative data

To ensure the integrity of the available data, i.e., accuracy, completeness and quality of the collected data (Cote, 2021), all data were checked for systemic and human errors. Inconsistent or illogical values (e.g., out-of-range values) were identified by comparing means, minimum and maximum values against logically accurate value ranges (see also 'data cleaning', Leibniz-psychology.org). Several cases of erroneous data were detected, including *date of birth* (e.g., 25/Nov/1899) and *total minutes of walking per week (e.g., 0 minutes)*. Where possible, erroneous values were corrected manually or otherwise treated as missing values. No duplicate observations, structural errors or errors due to multiple data sources were visible in the available data (see Appendix B.5 for manual error checking of the available data).

4.4.2.2 Eligibility and data splitting

Before exploring missing values, the data set was split according to eligible and ineligible participants (for eligibility, see Table 2 Comparison of the different stages of the applied mixed methods approach). All ineligible cases were removed to avoid erroneous overrepresentation of missing values caused by skip logic.

4.4.2.3 Normality testing and skewness

Violations of normal distribution were expected for most of the survey data, as substance use and related behaviour rarely follow a normal distribution (Field, 2017; Wagner, Riggs, & Mikulich-Gilbertson, 2015). Normality and skewness were tested for all continuous variables and computed sum scores. No testing was conducted for categorical variables (Mishra et al., 2019). The *Kolmogorov-Smirnov* and *Shapiro-Wilk* test of normality revealed significance values of $p<.001$ for all tested variables except the sum-score of benefits/barriers of physical activity (as assessed with the *Exercise Benefits and Barriers Scale,* EBBS) and mental health, thus suggesting a violation of the assumption for most included continuous variables (Pallant, 2016) (see Appendix B.5). Positive skewness of data was indicated for the summed risk scores of cannabis use, cocaine, amphetamine, inhalant, sedatives, hallucinogens, opioids, other substance use, tobacco dependence, and variables assessing physical activity participation; no severe skewness was detected for sum scores of experienced physical activity benefits/barriers (EBBS), age and alcohol risk (WHO ASSIST).

4.4.2.4 Independence of observations and homoscedasticity

Due to the anonymous nature of online data collection independence of cases was assumed; homogeneity of variances was not assumed for the highly skewed data.

4.4.2.5 Linearity

To investigate pre-existing assumptions of linear relationships (Degenhardt et al., 2016; Hall et al., 2016), the linearity of relationships between substance use, physical activity, and mental health summary scores were explored using scatterplots. Linear relationships were observed between the following variables: PA Benefits - PA Barriers; Total PA minutes/week - Total PA times/week; Treatment acceptability - PA benefits; Treatment acceptability - PA barriers; and PA barriers - Mental health. No linear or curvilinear relationships were found between any other continuous variables.

4.4.2.6 Value distributions

Value distributions were assessed for categorical variables. All investigated variables failed to support an assumption of equal value distribution within the set categories, with engagement with different substance types, sociodemographic environment and physical activity participation revealing numerous outliers.

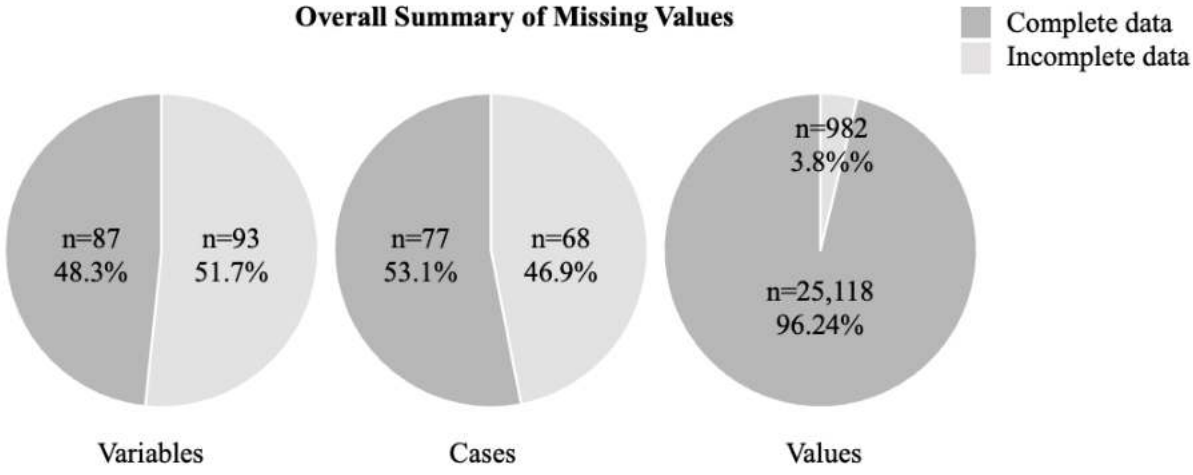
4.4.2.7 Missing values

Missing values, including the type *(missing at random* (MAR), *missing completely at random* (MCAR), *missing not at random* (MNAR), amount and potential underlying reasons (system-generated or used-defined), were investigated to mitigate any risks of reduced statistical power or sample representativeness or biased parameter estimates (Kang, 2013).

User-defined missing values or actual missing values were excluded pairwise. System-defined missing values, for example, missing values due to skip logic, were replaced with the number 0. By doing so, only user-defined values were included in the missing value analysis to achieve an accurate representation of actual missing values. When examining the overall amount of missing data in the context of all available data, only 3.8% of all data, and thus below 5%, were missing (see Figure 3). Additionally, missing values were investigated using a pattern analysis. No single variable or case was reporting an amount of missing data that would have justified an exclusion.

Figure 3

Summary of missing values



In addition to performing a pattern analysis, Little's Missing Completely at Random (MCAR) Test was performed for all variables representing sum scores using the SPSS Missing Value Analysis. The pattern of missingness was investigated via the Expectation Maximization (EM) method based on 1000 iterations to allow the EM algorithm to converge. With X^2=561.27 (590), p=.797 Little's MCAR Test was not significant, indicating that the missing values were missing completely at random.

With an overall amount of less than 5% of missing values, pairwise exclusion was chosen as an appropriate method for handling missing data in line with recommendations (IBM, 2012). Multiple imputation was judged to be unnecessary, mainly due to the analysis restrictions that commonly come with this approach of missing data handling.

4.4.2.8 Data manipulations

Several data manipulations were performed during data preparation.

Computing new variables

To allow for interpretation, summary scores were calculated for all included scales by summing up individual item scores using the compute function in SPSS (IBM, 2021, p. 61). All computed summary scores were added as additional variables/columns at the end of the existing dataset. Newly computed variables included age and substance use severity based on the substance-related level of risk (low, moderate, high risk; WHO, 2010).

Collapsing of categories

Collapsing categories, thus grouping a large number of response categories into a smaller number of categories, may achieve greater clarity of data and pattern, mainly when rarely used categories result in outliers and skewed data patterns (DiStefano, Shi, & Morgan, 2020). Collapsing data may further achieve higher convergence rates and increased accuracy in parameter estimates (DiStefano et al., 2020).

Categories were collapsed for several sociodemographic items with a large number of response categories and few responses in extreme categories, such as the category 'other' (referring to any responses not being accurately addressed in any other category). Collapsed items included *housing situation* (e.g., rental, homeowner), *current relationship status* (e.g., single, separated, de facto), and *current social living arrangement* (e.g., living with family, friends). Another collapsed variable was *overall substance severity for one or more substances* to the categories 'moderate risk' (coded 1) and 'severe risk' (coded 2).

Variable mapping

The reported postal codes were mapped onto areas of relative advantage and disadvantage according to *Socio-Economic-Indexes for Areas* (SEIFA). SEIFA ranks areas in Australia according to relative socio-economic advantage and disadvantage and consists of several different indices (ABS, 2022). The Index of *Relative Socio-Economic Advantage and Disadvantage* (IRSAD) was used to map the reported postcodes and derived local government areas onto a continuum investigating both relative advantages and disadvantages (ABS, 2023c). The IRSAD categorises Australian postcodes, local government areas (LGAs), or suburbs and localities according to deciles or ranks. For deciles, all postcodes are assigned a decile number between 1-10 according to their relative scores of disadvantage/advantage. For ranks, total scores of advantage/disadvantage or each area are ranked from highest to lowest score. The postcode with the lowest score (indicating the most disadvantage) is assigned rank 1 (ABS, 2023d). Additional variables for mapped deciles and ranks according to reported postcodes were added to the data set.

4.4.3 Quantitative method of analysis

4.4.3.1 Explorative analyses

Several explorative data analyses were performed. Due to the skewness of the data, as well as several violations of parametric assumptions, including normal distribution, robust methods

and non-parametric approaches were applied. Data transformation, thus transforming available data to fit assumptions for parametric tests better, was considered; however, both chi-squared and log-transformations did not lead to more normally distributed data. These findings together with the considerable controversy around data transformations in general (Grayson, 2004), led to a decision against using data transformations, but instead using robust methods and bootstrapping as a suitable alternative (Pallant, 2016; Tabachnick & Fidell, 2013).

To explore relationships among substance use, mental health, treatment acceptability and experienced barriers and benefits in relation to physical activity bootstrapped (10,000 resamples), Spearman's rank order correlations were calculated. To account for the assumed, however unknown, relationship of the included variables, a two-tailed approach was used. Using the bias-corrected accelerated method (BCa), accurate confidence intervals were estimated by implementing corrections to the standard confidence intervals of the bootstrap distribution. These corrections focus on nonnormality, bias and nonconstant standard error (Grün & Miljkovic, 2022).

For investigating differences among independent groups, depending on the number of groups, Mann-Whitney U Tests (nonparametric t-test for independent samples; 2 groups), Kruskal-Wallis Tests (one way between group analysis or variance; 3 or more groups) or Fisher's Exact Probability Tests (nonparametric analysis of 2 categorical variables, two or more groups) were computed. Findings were considered statistically significant if $p \leq .05$ with estimated confidence intervals not straddling zero.

4.4.3.2 Data mining

A data mining approach was applied due to the complex and highly distorted nature of the dataset, including variable intercorrelations, skewness, abnormal data distributions and rich context data (Koh & Tan, 2011). Data mining focuses on the detection of trends and patterns in large datasets and facilitates the description of latent patterns without limiting opportunities to exploration or losing the richness of the available data (Hand, 2007). Clustering, i.e. grouping participants according to similarities in multiple variables (Wu, 2012), and decision tree analysis were applied to explore treatment acceptability of physical activity interventions in young people aged 16-25 years with problematic substance use.

All data mining methods were conducted in R programming language using the packages tidyverse, cluster, and factoextra for clustering, and the packages caret and rpart for

regression analyses. The packages viridis and rpart.plot were utilised for data illustration, and the package haven was used for importing SPSS data files into R.

Clustering

In clustering, also called cluster analysis, participants are grouped into two or more homogenous clusters according to similarities in scores on several observable (i.e., "manifest") continuous variables. Variable means are used to explore the distance between cases and cluster membership derived thereof (Weller, Bowen, & Faubert, 2020). Nbclust() was used to compute the optimal number of clusters in R. The clustering method utilised for partitioning clustering was k-means clustering, which uses R to cluster data into k clusters (Wu, 2012).

Several manifest variables were explored, which were thought to contribute to treatment acceptability based on previous analyses in this study and existing literature (Goodman & Huang, 2002; McLaughlin, Costello, Leblanc, Sampson, & Kessler, 2012). These variables included physical activity participation (total minutes/ times per week), substance use (total substance scores), experienced benefits of and barriers to physical activity participation and age.

Decision tree

Regression tree analysis highlights variables with strong explanatory power regarding the variance in a model. Variable selection and recursive partitioning by conditional inference are performed by the applied generic algorithm (Hothorn, Hornik, & Zeileis, 2015). By doing so, regression tree analyses provide an informative model and visualisation of significant associations and thus may guide critical decisions (Morgan, 2014). The analytical approach was chosen to explore how critical relationships among participant characteristics held explanatory power within a model investigating treatment acceptability. Substance use, physical activity participation, experienced barriers to PA, treatment acceptability, mental health and sociodemographic variables were included in the analyses. The impact of participant characteristics on experienced PA barriers was explored, with barrier perception being used as an of treatment acceptability.

The R package tree was applied using the formula *tree(formula, data, weights, subset, na. action = na.pass, control = tree.control, method = "recursive.partition",...)* for fitting classification or regression trees. The packages caret, ggparty and partykit were used to fit and

visualise the computed inference tree appropriately. Bonferroni correction was used to adjust p-values to mitigate the risk of type 1 error. A 95% confidence interval was applied.

4.4.3.3 Data modelling

Data modelling approaches were used to explore the treatment acceptability of physical activity interventions, including *generalised additive modelling* GAM and *latent class analysis* LCA (finite mixture modelling). Latent class analysis is a statistical procedure used to identify latent (i.e., concealed or hidden) classes in similar populations. Grouping according to hidden classes is conducted by analysing similar patterns of observed (i.e., manifest) scores across categorical scales (Weller et al., 2020). Latent class analysis was performed to confirm or contradict the cluster analyses which were performed in the previous step. All data modelling computations were conducted in R using the packages poLCA (Muthen & Muthen, 2000) for latent class analysis and mgcv for generalised additive modelling.

Latent class analysis

Exploratory latent class analysis was used to explore latent groups within manifested categorical data by using expectation maximisation for model estimation (Cooper & Ajoku, 2018). Response patterns in categorical variables of interest were expected to differ between latent groups and agree within the same latent group. Conditional independence was assumed for all included variables. To allow for a good model fit, continuous variables were collapsed into categories; categorical variables with many categories were collapsed into fewer categories. Based on the cluster analysis and the existing literature, the following indicator variables were included: Experienced PA barriers, substance use, physical activity participation and mental health (Goodman & Huang, 2002; McLaughlin et al., 2012; Strohle et al., 2007).

The formula used within the poLCA package was poLCA (formula, data, *class = 2, maxiter = 50000, graphs = FALSE, na.rm = TRUE, nrep = 10, verbose = TRUE).* The number of model estimations was set to nrep=15 to allow the estimation of a global maximum rather than a local maximum. Each model estimation was computed with a different starting value. Model fit was evaluated with the help of the Bayesian Information Criterion, Akaike Information Criterion, and likelihood Ratio Chi-Square statistic. The interpretation and evaluation were guided by Cooper and Ajoku (2018).

Generalised additive modelling

Generalised additive modelling (GAM) was chosen due to its robust, nonparametric characteristics, which facilitate flexible predictive modelling without underlying assumptions of linear relationships. Relationships between predictor variables ("features") and the dependent variable within a GAM may be either linear or nonlinear. GAMs were fitted using the Restricted Maximum Likelihood Model (REML) to reduce the likelihood of overfitting the data; smoothing parameters were optimised (Clark, n.d.; Noam, n.d.).

Generalised additive modelling allowed flexible data fitting based upon underlying data rather than set parameters by integrating so-called "smoothing functions" (or "smooth") to illustrate relationships that are not perfectly linear. Smoothing functions attempt to approximate and capture linearity pattern in the data. The choice was based on the previously examined dataset which contraindicated the fit of simple linear models. Model comparisons were computed with the help of an ANOVA and by comparing the Akaike information criterion (AIC), generalised cross-validation (GCV) and adjusted r squared.

Data was examined by fitting single-feature GAMs (single predictor variable) and multiple-feature (multiple predictor variables) GAMS using the formula *model <- gam(y ~ s(x), data = my_data)*. Comparison plots were illustrated with *plot(tmodel_name, all.terms = TRUE, pages = 1)*. Relationships between treatment acceptability, experienced barriers to PA, mental health, PA participation, and substance use were examined. All analyses were guided by interactive learning tutorials by Ross Noam (noamross.github.io) and Michael Clark (m-clark.github.io). Additional data visualisation and manipulations were performed using the gratia and ggeffects packages, which are extensions of the ggplot 2 package. For the R assessment of linear and nonlinear model fit, see Appendix B.5.

4.4.4 Quantitative results

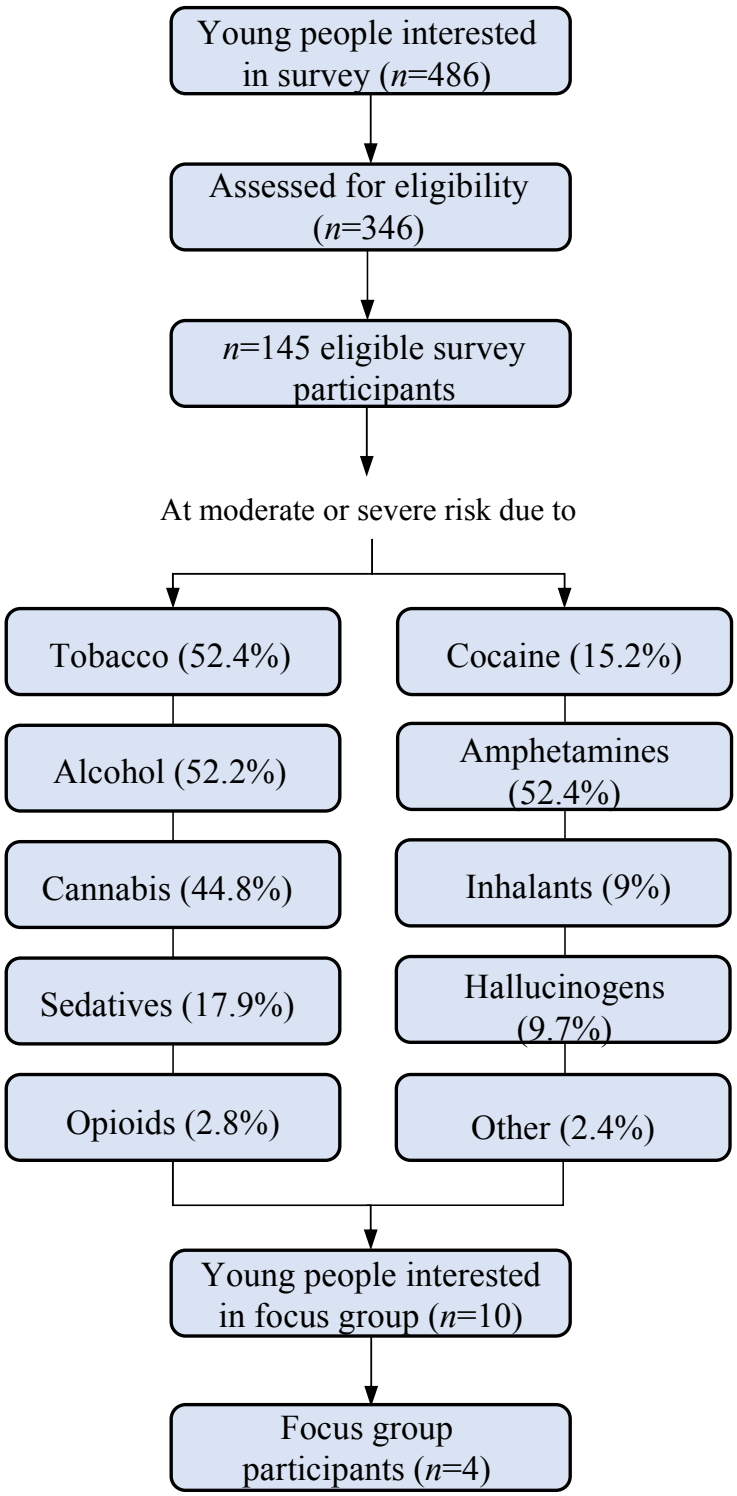
4.4.4.1 Descriptive parameters

Participation pattern, survey completion and drop-out rate

A total drop-out rate of 68.54% was recorded throughout the survey, which is common among young people with problematic substances (Bergman, Kelly, Nargiso, & McKowen, 2016; Leslie, 2008; Sussman & Sinclair, 2022).

Figure 4

Flowchart of survey and focus group participation



Participant characteristics

A detailed list of participant characteristics is provided in Table 4. Cannabis was classified as illicit within this study, as the study subpopulation was recruited from within Australia, i.e., a country where non-medical use of Cannabis is currently prohibited. The variable '*sufficient time'* was calculated to determine which young people engaged in sufficient physical activity to derive health benefits as per national and international physical activity guidelines. Participation in at least 150 min of physical activity per week was considered to be sufficiently active (sufficient time = continuous walking + moderate PA + (2x vigorous PA); AIHW, 2003).

Young people reported a mean benefits score of *M*=97.02 (BCa 95% CI [94.56, 99.64]), indicating an overall strong perception of physical activity benefits. For perceived barriers, young people reported a mean score of *M*=38.0 (BCa 95% CI [36.6, 29.39]), indicating an overall lower perception on barriers relative to benefits.

An average sum score (i.e., added scores divided by number of questions) and total sum score (i.e., added scores) were calculated to assess the treatment acceptability of PA interventions in young people (Sidani et al., 2009). Sum scores indicated an overall treatment acceptability (i.e., individual items added up) of *M*=2.38 (BCa 95% CI [2.23, 2.54]) or scaled sum score of *M*=9.52 (BCa 95% CI [8.93, 10.17]) indicating general good acceptability.

Table 4

Descriptive participant characteristics

Characteristic	% (*n*)	*M* [BCa 95% CI]
Substance risk (prevalence)		
Moderate risk	77.2% (112)	
High risk	22.8% (33)	
Only legal SU	16.6% (24)	
Legal & illicit SU	83.5% (121)	
Single drug use	14.5% (21)	
Polydrug use	85.5% (124)	
Injecting use	4.1% (6)	
Sociodemographic information		
Female	71.5% (103)	
Male	22.2% (32)	
Other	6.3% (9)	
Aboriginal/Torres Strait Islander	3.5% (5)	
IRSAD		
Severe disadvantage	25.9% (37)	
Advantage	74.2% (108)	
PA participation (average)		
Walking min/week		315.1 min [239.89, 396.76]
Moderate PA min/week		78 min [39.55, 134.8]
Vigorous PA min/week		120 min [87.83, 149.86]
Heavy yard work		64.6 min [37.37.61, 93.6])
Total PA min/week		577.7 min [493.93, 823.48]
Guideline concord PA		
Sufficient PA (sufficient time)	51% (74)	
Insufficient PA	19.3% (28)	
No information (i.e., missing)	29.7% (43)	

4.4.4.2 Relationship and subgroup analyses

Relationship (i.e., correlation) analyses were conducted using Spearman rank order correlation. There was a small correlation of cocaine and methamphetamine use risk scores with age, as well as an association of poor mental health (K10) and nicotine use risk scores. Further, increased perception of PA benefits was associated positively with increased PA participation and increased mental health; increased perception of barriers in turn was associated with decreased PA participation and poor mental health (see Table 5). No significant correlations between treatment acceptability and substance use risk or PA participation were identified.

Table 5

Intercorrelations of substance use, mental health, treatment acceptability and PA barriers and benefits

Variable	Age	Nicotine dependence	Tobacco use	PA times/ week	Mental health	Treatment acceptability
Cocaine use	.24**	—	—	—	—	—
Amphetamine use	.18*	—	—	—	—	—
Mental health	—	.22*	.65**	-.22*	—	—
Perceived PA benefits	—	—	—	.22*	.28**	.52**
Perceived PA barriers	—	—	—	-.42**	-.43*	-.3**

*p<.05. **p<.01.

Treatment acceptability was further positively correlated with several distinct PA barriers (Table 6) and PA benefits (Table 7). A selection of correlations at p<.01 has been presented in tables 6 and 7. For smaller correlations see appendices. Other benefits significantly related to increased treatment acceptability included improved functioning, exercise enjoyment, social connection, and improved well-being.

Table 6

Intercorrelation of treatment acceptability (TAP) and distinctive barriers (EBBS)

Variable	My family members do not encourage me to exercise	Exercise takes too much of my time	Exercise is hard work for me	Physical activity increases my substance use

Treatment acceptability	-.32**	-.27**	-.27**	-.32**

Note. Only correlations with p<.01 listed

**p<.01

Table 7

Intercorrelation of treatment acceptability (TAP) and distinctive PA benefits (EBBS)

Variable	Exercise decreases feelings of stress and tension for me	Exercise improves my mental health	Exercise prevents low mood	Exercise decreases feelings of stress and tension for me
Treatment acceptability	.53**	.48**	.46**	.53**

Note. Only correlations with p<.01 listed

**p<.01

Subgroup analyses showed that young people at high substance-related risk (due to the use of one or more substances) experienced significant poorer mental health (as indicated by increased psychological stress) and more PA barriers than young people at moderate substance-related risk (Table 8). Further, gender analyses revealed that young people who identified as male reported overall higher values of PA participation than people who identified as female or "other", including for total minutes of PA/week (χ^2 (2, n=99)=10.40, p=.006, r=.33), total min of walking/week (χ2 (2, n=132)=8.57, p=.014, r=.26), and total min of moderate PA/week (χ^2 (2, n=109)=8.08, p=.018, r=.47). No gender differences were detected for substance use. Detailed results on all conducted correlation (i.e., relationship) and subgroup analyses can be found in Appendix B.6.

Table 8

Differences in mental health and PA barriers according to substance use risk level

Substance use risk (N=128)	Moderate risk		High risk		*z*	*p*	*r*
	Mdn	*n*	*Mdn*	*n*			
Mental health	25	96	33	32	4.02	≤.001	.2
Perceived PA barriers	38	110	43	33	2.53	.011	.3

Note. Differences between two independent groups were detected using a Mann-Whitney U test, for three or more groups, a Fisher's Exact Probability Test was conducted. Missing values were excluded test-by-test. Effect sizes were calculated manually with *r = z / square root of N*. *Mdn*=Median

4.4.4.3 Data mining and modelling

Cluster analysis

A cluster analysis was performed to explore the potential grouping of participants according to similarities in their characteristics. While the analysis initially indicated 2 clusters, the clusters were not found to be substantially different to be considered clinically relevant clusters. This implies that the similarities between the characteristics of the young people were high, despite the participant population including young people with different substance use (risk) levels, i.e., young people at moderate or severe risk. These similarities precluded the ability to distinguish discrete clusters pertinent to treatment decisions.

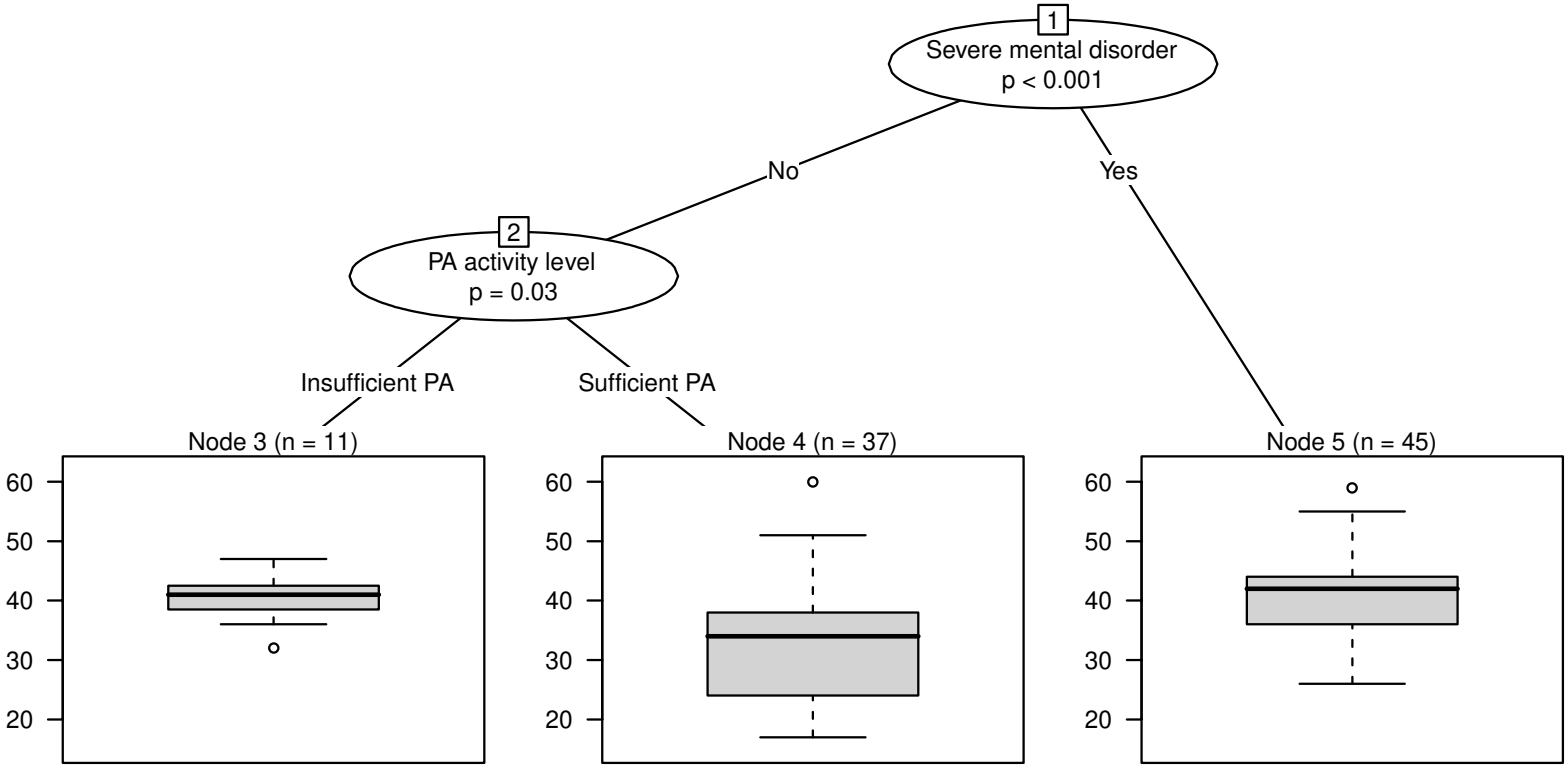
Regression tree analysis

No significant effect was found for treatment acceptability and PA participation or substance use. However, as PA barriers were previously established as significant predictor of treatment acceptability, the variable was used as an indirect indicator of treatment acceptability. "Mental disorder" (yes/no) was previously assessed with the K10, with high levels psychological distress (scores>30) indicating a likely presence of severe mental disorder.

The conditional inference tree revealed mental disorder and PA activity level as the strongest predictors of experienced PA barriers (Figure 5). Indicated presence of severe mental disorder comprised the first partition of the inference tree, with PA activity level comprising the second partition. The first partition indicated that young people with a high chance of experiencing severe mental disorder (n=45, Node 5) significantly differed from young people with no indication of severe mental disorder regarding their perceived barriers to physical activity. The latter group of young people was further partitionable according to their PA activity level (partition 2), with young people engaging in sufficient PA (n=37, Node 4) significantly differing from young people who were insufficiently active (n=11, Node 3) regarding their experienced PA barriers. With a mean value of M=41.51 and being the largest participant group, young people with severe mental disorders recorded the highest mean value of PA barriers. In turn, young people experiencing no severe mental health disorder and engaging in sufficient PA to gain health benefits recorded the lowest mean value of experienced PA barriers (M=32.73, Node 4), and thus likely expressed the highest treatment acceptability of PA interventions. For R assessment of the inference tree, see Appendix B.7.

Figure 5

Conditional inference with indicated severe mental disorder and PA activity level as independent variables and experienced PA barriers as dependent variable



Latent class analysis

The latent class analysis revealed a good fit for a 2-class model with a global maximum log-likelihood of -394.186. The model was based on the following indicator variables: Severe mental disorder (yes/no), sufficiently active to experience health benefits (yes/no), perceived PA barriers (low/high), treatment acceptability (low/high) and overall substance risk level (moderate/high).

When evaluating model fit, the chosen 2-class estimation indicated overall good model fit as indicated by the minimised Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) compared to models with more than two latent classes. Similarly, the likelihood ratio and chi-square statistic were minimised in the 2-class model. A total of 93 cases were included, and the number of degrees of freedom used by the model was 11. A comparison of different latent class models regarding model fit can be found in Table 9.

Table 9

Comparison of BIC to assess the best model fit

Estimated no. of latent classes	Bayesian Information Criterion
2[a]	843.1161[a]
3	869.578
4	895.1672
5	922.4371
6	950.6726, negative degrees of freedom
7	979.9069, negative degrees of freedom
8	1009.662, negative degrees of freedom
9	1039.522, negative degrees of freedom
10	1069.383 negative degrees of freedom

Note. BIC=Bayesian Information Criterion, no.=number

[a] best model fit as indicated by minimised BIC

Conditional item response probabilities for the investigated variables showed a 74.24% chance of participants in latent class 1 to experience only mild to moderate psychological distress, a 76.78% chance for them to be sufficiently active, a 91.62% chance for them to perceive PA barriers as low, a 61.18% chance of perceived high treatment acceptability and a 96.12% of them being only at moderate risk because of their substance use.

For latent class 2, response probabilities revealed a high chance (78.8%) of participants to experience severe mental disorder, a 67.11% chance of them being sufficiently active, an almost equal chance of them having low perception (41.16%) and high perception of PA barriers (58.84%), a slightly higher chance of them expressing low treatment acceptability (56.61%) and an overall equal chance of being at moderate (51.92%) or high risk (48.08%) because of their substance use.

Summarised, it can be said that participants in latent class 1 were likely to experience better mental health (i.e., less psychological distress), perceive fewer barriers to physical activity, have a lower risk status because of their substance use and express higher treatment acceptability and higher physical activity levels. Latent class 2, in turn, was more likely to include individuals with higher perception of PA barriers, higher substance use risk levels, lower treatment acceptability of PA, severe mental distress and less sufficiently active. In latent class 1, the estimated proportion corresponding to the share of observations was 57.28%; in latent class 2, it was 42.72%. This indicates that latent class one was slightly larger than latent class two.

Notably, while the analysis supported a 2-class model, thus indicating the presence of two latent classes among participants, these findings needed to be interpreted cautiously regarding clinical relevance. While the two classes showed clear differences regarding some variable dimensions, such as substance risk and mental distress, they did not show clear differences regarding others, such as physical activity participation (sufficient PA vs insufficient PA to gain health benefits). This indicated that the two latent classes cannot be clearly differentiated according to all investigated variables; overlap may likely occur. As a result, findings agreed with the cluster analysis above, in which results also indicated a 2-cluster solution; however, clusters were not found to be clinically relevant. For the R output of the latent class analysis, see Appendix B.8.

Generalised additive modelling – Single feature

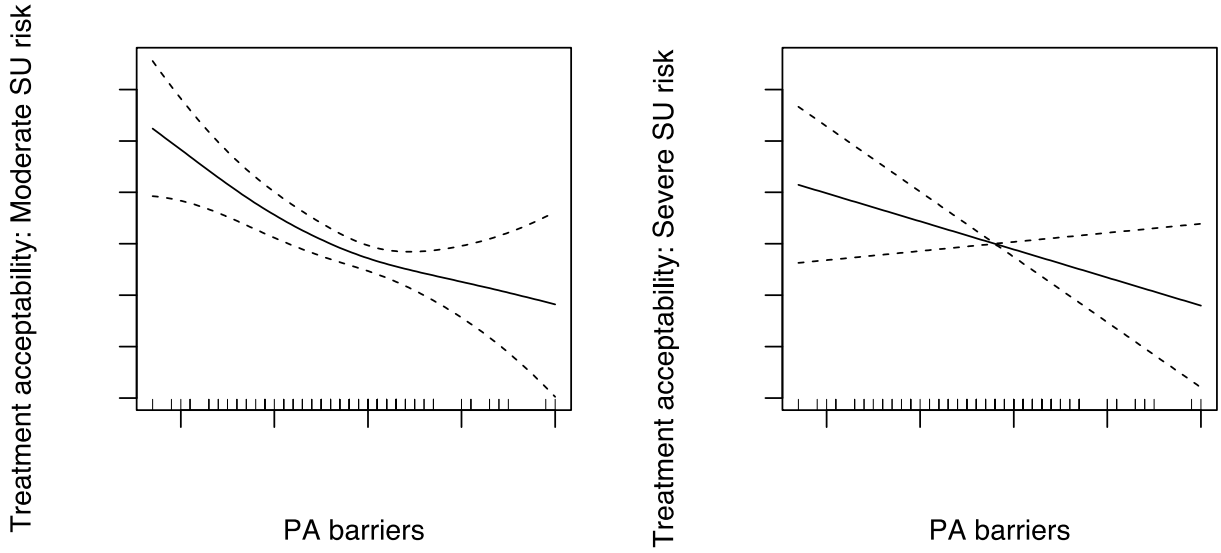
Treatment acceptability was assessed as a function of a single feature, i.e., experienced PA barriers. The results indicated that the outcome variable *treatment acceptability* can be represented as a nonlinear smooth function of the predictor variable *Experienced barriers to PA* as indicated by a comparison of best model fit according to AIC, GCV and r-squared. Both the intercept and experienced barriers were significant at $p \leq .001$, indicating that experienced barriers were a significant (nonlinear) predictor of treatment acceptability, with treatment

acceptability decreasing with increasing barrier perception. While the low amount of explained variance indicated the presence of additional predictor or confounding variables, no other relevant predictor variables (e.g., PA participation, mental health) were identified, thus indicating the presence of additional potential predictor variables that were not assessed as part of the research questionnaire.

When comparing the nonlinear relationship of experienced barriers as a predictor of treatment acceptability for young people at different levels of substance-related risk, the general additive model revealed different smooths for young people at moderate risk compared to young people at high risk because of their substance use. A weak nonlinear effect was found for young people at moderate risk but not young people at severe risk (linear effect). The former also demonstrated a significant effect, with a stronger decrease in treatment acceptability being associated with increasing experienced barriers. For a comparison of young people at moderate and high risk, see Figure 6 (see Appendix B.9 for R output).

Figure 6

Predictor function of experienced barriers for treatment acceptability by substance risk level (moderate, severe)

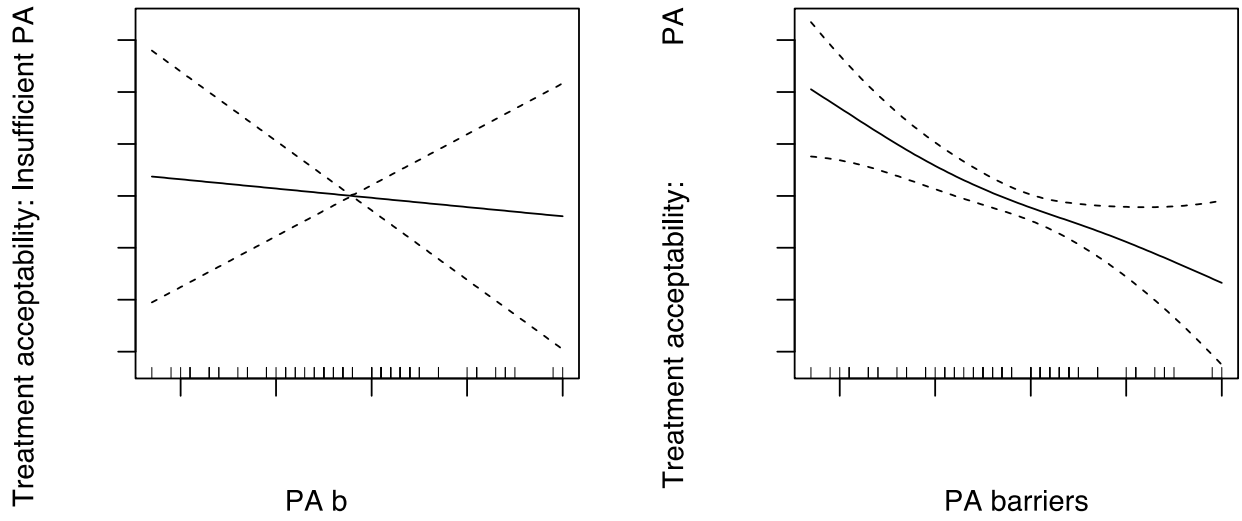


The nonlinear relationship of experienced barriers as a predictor of treatment acceptability differed for young people who engaged in sufficient PA compared to young people not engaging in sufficient PA. A slightly stronger, nonlinear relationship between exercise barriers and treatment acceptability was found for young people engaging in sufficient physical activity,

indicating that decreased experience of barriers leads to higher treatment acceptability for this group. Notably, the nonlinear relationship needs to be considered as part of this inference. For young people not engaging in sufficient PA, there was a much weaker, linear relationship between experienced PA barriers and treatment acceptability. For a comparison of young people engaged in sufficient PA vs not engaged in sufficient PA, see Figure 7 (for R output, see Appendix B.10).

Figure 7

Predictor function of experienced barriers for treatment acceptability by level of PA participation (sufficient/insufficient to gain health benefits)

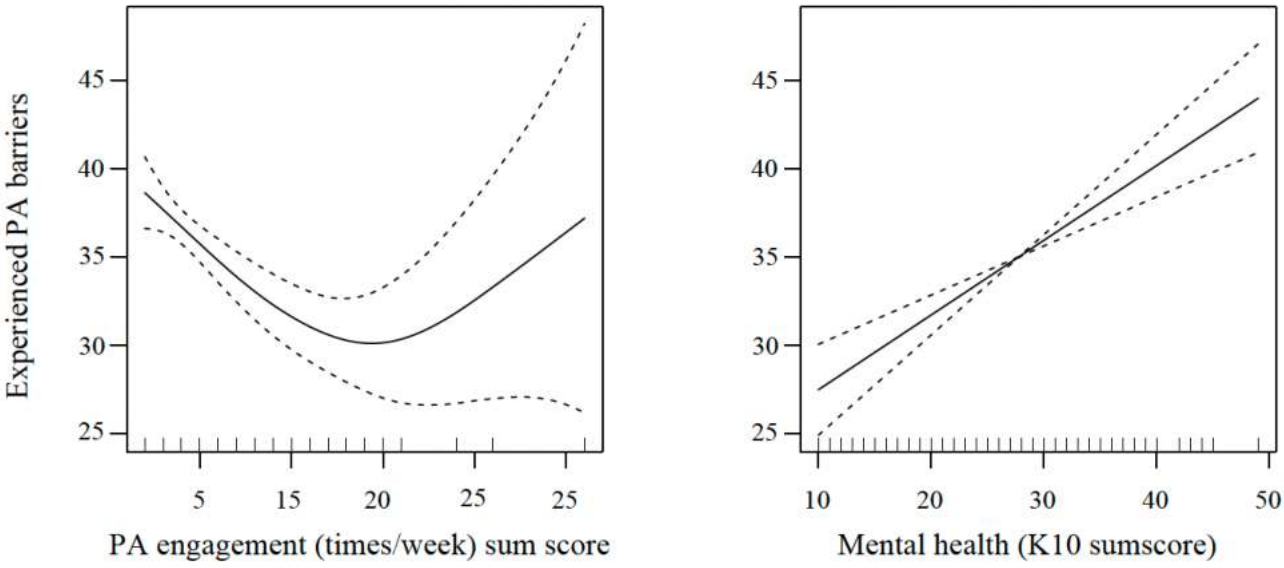


Generalised additive modelling - Multiple features

Experienced PA barriers were assessed as a function of multiple features, i.e., mental health and PA participation. Mental health ($p \leq .001$) and the amount of PA participation per week (in times/week) ($p \leq .001$) were found to be highly significant predictors of experienced barriers to physical activity. The relationship between PA times/week and experienced barriers was found to be nonlinear ($edf = 2.55$), the relationship between mental health (K10) and experienced barriers was linear ($edf = 1$) (see Figure 8). The combination of linear and nonlinear (smooth) terms explained overall deviance of 36.7% ($n = 123$) indicating the presence of additional potential predictor variables of experienced barriers to physical activity that were not assessed in this study (for R output see Appendix B.10).

Figure 8

GAM of experienced PA barriers as predicted by features of mental health and PA participation (times/week)



Overall, quantitative analyses suggested several subgroups of young people could be considered when integrating PA interventions into existing treatment for young people with problematic substance use.

According to the correlation analyses, there were significant associations between perceived benefits to PA, perceived barriers, mental health, PA participation and treatment acceptability. Young people experiencing many barriers to PA participation reported poorer mental health, decreased PA participation (PA times/week) and expressed lower acceptability of PA interventions ("treatment acceptability) than young people who experienced more benefits of PA engagement. Findings were confirmed and strengthened by subsequently conducted data mining and modelling.

A latent class analysis indicated a 2-class model fit, with one class experiencing significant lower psychological distress, reporting lower substance-related risk and fewer barriers to PA participation than the second class. The identified classes did not differ substantially in their PA participation and reported acceptability of PA interventions.

The tested generalised additive models confirmed the previously detected significant relationships between perceived PA barriers and treatment acceptability; barrier perception was thus identified as a significant (slightly nonlinear) predictor of treatment acceptability. A

second GAM revealed mental health and physical activity participation (times/week) to be significant predictors of experienced/perceived PA barriers.

Similarly, regression analyses confirmed that mental health and physical activity engagement predict perception of PA barriers. Young people who are unlikely to be experiencing severe mental disorder according to the K10 and who engage in sufficient PA according to international guidelines experience the lowest number of barriers to PA. Young people who are likely to be experiencing severe mental disorder report the highest number of barriers to PA.

4.5 Qualitative Focus Group

A qualitative focus group was conducted to allow for an in-depth exploration of factors relating to treatment acceptability regarding the integration of physical activity interventions for young people with problematic substance use. The focus group was performed according to an established framework of participatory design (Hagen et al., 2012), which highlights the employment of creative, qualitative methods such as brainstorming as part of focus groups to help young people communicate (Hagen & Rowland, 2011). By using a focus group, young people were invited to engage in the research process, and to share their perspectives and experiences.

4.5.1 Method

An online whiteboard technology was used to facilitate the focus group (https://miro.com/online-whiteboard/). Participants were invited into a respectful and inclusive dialogue; predefined questions were based on the survey outcomes and moderated by the PhD candidate. A second senior member of the research team was present as a silent moderator. Data was collected using audio and video recordings, and written creative output was collected using the whiteboard online software.

4.5.1.1 Focus group: Sample and eligibility

Young people aged 18-25 years who previously completed the anonymous online survey were invited to participate by opting-in to the focus group at the end of the survey. The opt-in option allowed young people to access the participant information and consent forms for focus group participation (Appendix C.1-C.2). To mitigate the risk of adverse events, including the

presence of suicidal ideation or suicidality, young people's current mental health was assessed at the start of the focus group.

The focus group included 4 participants. While a common recommendation for focus groups within applied research advises a slightly larger group size of 6-12 participants (Baumgartner, Strong, & Hensley, 2005; Central Connecticut State University, n.d.; Johnson & Christensen, 2008; Richard A. Krueger & Casey, 2015), Richard A. Krueger and Casey (2015) recommended that a smaller size enables a superior exploration of more complex topics which require delicate moderation.

4.5.1.2 Focus group format

The semi-structured focus group schedule (see Appendix C.3) was developed using several established guidelines (R. A. Krueger, 2002; Richard A. Krueger & Casey, 2015). Predefined questions were used to guide the focus group; however, the semi-structured design allowed additional in-depth exploration of themes. Questions regarding different intervention modalities were drawn from the extensive literature comparing the efficacy of intervention modalities (Foster, Hillsdon, Thorogood, Kaur, & Wedatilake, 2005; Marcus et al., 2006). Questions regarding the benefits of PA and PA interventions and barriers to PA and PA interventions in turn were based on findings from the quantitative research survey, that was conducted before the focus group (see chapter 4.4 Quantitative Research Survey).

4.5.1.3 Social desirability

The aspect of social desirability was judged minimal in the context of the focus group. Known themes with the potential to trigger socially desirable response patterns (i.e., inaccurately reporting illegal substance use and/or individual physical activity participation) were not the subject of the group discussion as they had already been captured anonymously as part of the survey.

4.5.2 Qualitative method of analysis

The focus group was recorded and transcribed verbatim. Data was analysed using qualitative content analysis to explore common themes and content related to the integration of physical activity interventions on a broader scale. Participants were assigned a unique code to de-identify their data, which was used in the reporting of results (e.g. Young person (YP) 1, YP 2, YP 3).

4.5.2.1 Qualitative content analysis

Content analysis was performed to capture the provided data appropriately and identify preferences and experiences communicated by young people. In qualitative content analysis, a factist perspective is applied, which assumes data to be an accurate representation of participants' actual perspectives (Vaismoradi, Turunen, & Bondas, 2013).

A manifest content analysis, i.e. a content analysis of the spoken words and written text, was performed to capture the surface structure and easily identifiable targets within the written and spoken text (Bengtsson, 2016; Vaismoradi et al., 2013). In this type of analysis, codes are derived directly from data and defined during the analysis process rather than before the analysis (Hsieh & Shannon, 2005). The chosen method allowed to identify concepts within the text and organise the text according to categories and themes (Kleinheksel, Rockich-Winston, Tawfik, & Wyatt, 2020).

Several inductive and deductive steps were followed to create and derive codes, as well as organise them according to categories and sub-categories. As a first step, immersion in the available data was achieved by meticulously reading through and becoming familiar with the transcribed data. Overarching categories based on the available interview text were deducted and documented. Following, *units of meaning* and *condensed units of meaning* were extracted from the focus group interview - statements or phrases representing a single idea or concept, which are subsequently shortened and condensed to only a few words while retaining the original meaning (Erlingsson & Brysiewicz, 2017; Kleinheksel et al., 2020). Meaning units were subsequently cleaned of verbal disfluencies (breaks or disruptions in speech) and condensed as a two-part process without assigning any implied interpretation.

As a third step, detailed *codes* and *categories* were developed inductively and deductively. Categories were predominantly deduced from existing questions; codes, however, were both derived from condensed meaning units and compared to preliminary established categories and sub-categories. Since several codes appeared to fit into multiple categories, *sub-categories* were developed to mitigate the risk of information loss caused by large jumps from codes to categories (Erlingsson & Brysiewicz, 2017). Established codes were used as a coding scheme for subsequent coding. Final codes were compared and adapted across all questions and themes to maximise uniformity and comparability, as well as allow analysis of patterns both within and across different themes. Notably, depending on different coding contexts,

seemingly identical codes were occasionally assigned to different sub-categories or categories (see Table 10). For a detailed list of the qualitative content analyses, see Appendices C.7-C.8.

Table 10

Context-dependent identical codes

Example	Context	Condensed Meaning Unit	Code	Sub-Category	Category
A	Superiority of PA interventions to existing mental health treatment	Group programs are motivating	Motivation increase	Group PA	PA intervention benefits
B	Consequences of service-led implementation of PA facilitators	Tailored PA increases motivations	Motivation increase	Tailored PA	Service provision

As a fourth step, common themes across categories were identified. While categories commonly carry the manifest content of the investigated data, themes may be used as an interpretive abstraction of the literal meaning and may carry emotional or even metaphorical information (Erlingsson & Brysiewicz, 2017). While themes are traditionally used more in the thematic analysis (Vaismoradi & Snelgrove, 2019), they are also appropriate to acknowledge meaningful context within qualitative content analysis (Kleinheksel et al., 2020).

Quality criteria

Several steps were taken to increase the quality of the analyses, such as following an established checklist for improving "trustworthiness" (e.g., quality) within a content analysis and constructing a detailed coding book (Elo et al., 2014). The coding book, i.e. detailed documentation of the followed coding scheme, aimed to increase coding consistency, reliability and reproducibility and details each code, code descriptions and relevant code examples (Hsieh & Shannon, 2005). Codes were first derived from condensed meaning units, compared with pre-established categories, and documented in the code book (see Appendix C.6). If no existing code could be assigned to the condensed meaning unit, or codes appeared to be incongruous with the sub-category or category they were assigned to, new codes were developed. To reduce the risk of *coder fatigue*, coding was performed over several sessions (Kleinheksel et al., 2020).

4.5.3 Qualitative results

4.5.3.1 Qualitative content analysis

The following data represents young people's thoughts and perceptions regarding the (hypothetical) integration of targeted physical activity into existing substance use treatment services for young people.

A total of 77 distinct codes across five broad themes were identified within the available focus group data, including the outputs of spoken conversation and written brainstorming (see Appendices C.4-C.5). Each theme incorporated several categories. The five questions making up the themes were:

(1) Why does integrating physical activity into existing substance use treatment services make sense to young people? (Short: Why does it make sense?)
(2) What barriers hinder young people from engaging in physical activity or targeted physical activity interventions? (Short: What are the barriers?)
(3) What are previous experiences of young people with services and behaviour change? (Short: What are past experiences?)
(4) What do young people want to see implemented, and what are their expectancies and preferences regarding physical activity interventions delivered by mental health services? (Short: What do young people want?)
(5) What actions could services take, and which intervention elements could services implement to reduce barriers and support the integration of tailored physical activity interventions? What may these actions lead to? (Short: What can services do?)

Benefits of PA and PA interventions

Young people identified numerous benefits related to PA and PA interventions if routinely integrated into substance use treatment services. Benefits associated with physical activity participation in general included mental health benefits (i.e., empowering feelings), motivational benefits (i.e., increased motivation to quit), benefits to life structure (i.e., regular routine) and physiological benefits (i.e., dopamine and energy increase) associated with physical activity participation. Another reported benefit, the behavioural domino effect, describes a benefit in which an increase in one health behaviour leads to a subsequent rise in other behaviour, such as increased healthy eating.

Perceived benefits directly related to participating in a physical activity intervention included substance use benefits (i.e., substance use reduction), life structure (i.e., added direction in life), and benefits related to group facilitation such as motivation increase and positive feelings (i.e., feeling of responsibility). Young people identified similar behavioural domino processes associated with physical activity interventions. These also included improved healthy eating and social encouragement initiated by such interventions. For a complete list of benefits, see Table 11.

Table 11

Perceived benefits of PA as seen by young people

Theme	Why does it make sense? - Why does integrating physical activity into existing substance use treatment services make sense to young people?									
Category	PA benefits					PA intervention benefits				
Sub-category	Mental health	Motivation	Life structure	Physiological benefit	Behavioural domino effect	SU benefits	Behavioural domino effect	Life structure	Group benefits	Positive feeling
Code	Mental health benefits Empowering	Increased quit motivation	Regular routine (2)	Dopamine increase Energy increase	Healthy eating (2) Social encouragement Behavioural domino effect	Added SU benefits (4)	Healthy eating (2) Social encouragement (3)	Adding direction	Motivation increase	Sense of responsibility

Note. Encased numbers indicate numbers of code citation "(1)"

Barriers to PA and PA interventions

Young people reported experiencing several barriers to engaging in physical activity and physical activity interventions if integrated into substance use services. These barriers related to either service access or physical activity participation. In the former category, young people reported experiencing logistical barriers (i.e., transportation barriers, lack of resources to reach services or proximity barriers such as services being located far away) and access barriers (i.e., access barrier by age, access barrier by knowledge). Notably, young people explained that it took significantly more work to access services with age, as young adults are expected to organise service access themselves rather than receiving support in doing so.

Barriers to physical activity participation were categorised by four sub-categories: Service-induced barriers, substance use barriers, social barriers, and "other" barriers. Service-induced challenges to physical activity participation referred to vague recommendations provided by clinicians and potentially inappropriate service models. Examples of unsuitable service models include facilitating unsupervised physical activity interventions during treatment stages in which engagement and motivation had not been established; thus, facilitation of such a model might lead to disengagement and lack of motivation. Barriers included in the social sub-category related to social challenges such as confidence and fitting in, negative group dynamics, and cultural and gender barriers.

Substance use was perceived as a substantial barrier to physical activity participation. Young people described the negative impact of substance use on physical activity participation with numerous examples, such as substances affecting exercise motivation, sleep, energy, drug comedown, fitness and financial resources allocated to physical activity (e.g., gym membership, exercise equipment). A comprehensive list of perceived barriers can be seen in Table 12.

Table 12

Barriers to PA and PA intervention experienced by young people

Theme	What are the barriers? - What barriers hinder young people to engage in or in PA or in targeted PA interventions?					
Category	Barriers to service access		Barriers to PA participation			
Sub-category	Access barrier	Logistical barriers	Service-induced barriers	SU barriers	Social barriers	Other barriers
Code	Access barrier by age (1) Access barrier by knowledge (1)	Proximity barrier (1) Transportation (1) Resources barrier (1)	Vague recommendations (1) Inappropriate treatment model (4) (e.g., unsupervised PA reduces motivation, allows disengagement (2), supervised PA may be too intense (1))	Negative impact of SU (11) (e.g., Cannabis affects motivation (1), smoking affects fitness (1), SU affects motivation (2)/energy (1), SU affects sleep (1), SU increases barriers (1), SU affects finances (2), smoking and drinking affects motivation (2), drug comedown (1))	Social barriers (1) Group dynamics barrier (1) Cultural barriers (1) Gender barriers (1)	Progress barrier (1) Variety barrier (lack of) (1) Technological barrier (1)

Note. Encased numbers indicate numbers of code citation "(1)"

Perceptions of behaviour change

Young people expressed a clear preference for behaviour change interventions compared to structural interventions. Behaviour change interventions are defined as '*coordinated sets of activities designed to change specified behaviour patterns*' (Michie, Van Stralen, et al., 2011). Structural interventions refer to interventions aiming to change the environments which determine health behaviours, including social, physical, and economic environments (Brown et al., 2019). Perceived barriers to behaviour change were mental disorder and the level of difficulty associated with behaviour change. A comprehensive list of reported experiences related to behaviour change can be seen in Table 13.

Table 13

Young people's previous experiences

Theme	What are past experiences? – What are previous experiences of young people with services and behaviour change?		
Category	Behaviour change experiences		Service experiences
Sub-category	Facilitators	Barriers	Services experiences
Code	Creating habits (1) Empowering (2) Easier with time (3)	Hard (4) Mental illness (1)	Service experience (2) (neutrally described) Positive service experience (1)

Note. Encased numbers indicate numbers of code citation "(1)"

Young people's preferences regarding physical activity interventions

Young people expressed clear preferences regarding physical activity interventions, which were grouped into three categories: Clinician preferences, intervention preferences and facilitation preferences. Regarding clinicians who may integrate physical activity interventions, young people preferred knowledgeable clinicians (i.e., knowledge in the facilitation of physical activity) who can provide clear directions as to where, how, how long, and at what intensity for young people to perform physical activity. Additionally, young people emphasised the importance of a clinician's passion and motivation for physical activity.

Preferred interventions included highly tailored and individually facilitated rather than group-based interventions. While the benefits of group-based interventions were noted several

times in different contexts, such as their potential to increase motivation, individual interventions were favoured due to their flexible nature. Supervision preferences (i.e., supervised versus unsupervised physical activity) were predominantly related to treatment stages. Supervised physical activity was favoured in early treatment stages when routines had not yet been established. During later treatment stages, however, young people expressed a preference for planned, unsupervised physical activity or unsupervised physical activity altogether.

In the sub-category of facilitation preferences, young people endorsed both in-person and mixed facilitation (i.e., in-person and online facilitation). While peer support was acknowledged as beneficial in some contexts, there was a clear preference for optional peer depending on a young person's preference. A detailed list of preferences regarding physical activity interventions can be seen in Table 14.

Table 14

Young people's preferences in PA interventions

Theme	What do YP want? - What do young people want to see implemented; what are their preferences regarding PA interventions delivered by mental health services?		
Category	PA intervention preferences		
Sub-category	Intervention preferences	Clinician preferences	Facilitation preferences
Code	Individual PA (7) (e.g., allows flexibility) Supervised PA (2) (in beginning; for accountability) Unsupervised PA (habits established) (1) Tailored PA (6) Behaviour change intervention (5) PA variety (2) Planned, unsupervised (3)	Knowledgeable clinician (1) Clear directions (3) Passionate clinician (2) Motivating clinician (1)	Physiologist facilitator (4) Mixed facilitation (2) In-person facilitation (2) Optional peer support (10)

Note. Encased numbers indicate numbers of code citation "(1)"

Young people's desired service steps regarding integrated physical activity interventions

Lastly, young people expressed preferences regarding steps to be taken by health services, which, according to young people's perceptions, may facilitate increased PA participation, reduce barriers to PA and increase participation in PA interventions. The expressed preferences were grouped into three categories: Service provision, service processes and service-led barrier reduction. The latter described psychological and behavioural implications of successful reduction of experienced barriers such as a motivational increase, an increase in the perceived value of physical activity participation, positive feelings (e.g., less worry) and feelings of appreciation and being valued by services. Preferred steps to be taken by services within the category of "service processes" related to increased progress checking, increased choice and information sharing among different members of the treating service team.

Within the category of service provision, young people envisioned additional steps on the service provider's side to improve access to services as a requisite for accessing PA interventions. In relation to improved service access for young people, a need for better access using local cooperation (e.g., cooperation between mental health services and schools or workplaces to allow for time to participate in PA or PA interventions), organisational support (e.g., help with scheduling PA sessions), and improved access by proximity (i.e., reduced distance to services) were expressed.

Additionally, engagement aids were suggested by young people as a potential service step, including reward systems (e.g., token systems) for successful progress in physical activity interventions, hearing positive testimonies from young people who have completed such interventions, providing social connection (e.g., creating a network of people doing similar exercise), and designing physical activity interventions that could facilitate social encouragement. Notably, rewards systems and social factors have been highlighted as BCT for increasing PA behaviour in chapter 3.4 Impact of BCT on PA Interventions: Publication 2.

Strategies services can provide to help young people decide if they wanted to participate in a physical activity intervention and what options they wanted to try included providing a list of available options for engaging in PA, facilitating a larger number of available options, providing young people with a "run through" of the entire intervention and offering informative education on such interventions (e.g., what are the potential personal treatment benefits of such interventions, what are the potential long-term benefits). One young person explained that it

would help them decide if they knew that a physical activity intervention was connected to a local sports team, as this would be a highly motivating factor for them.

Additional facilitators which would help young people to participate in physical activity overall included having additional psychological support, low-cost physical activity, having a large variety of options to choose from, organisational support in setting up physical activity sessions and learning more about the benefits of physical activity overall and on substance use. Other facilitators included having a physical activity expert readily available on the premises of a health service and using measurable goal-setting as a motivator. A list of desired service steps can be found in Table 15.

Table 15

Desired service steps regarding the integration of PA

Theme	What can services do and what would it lead to? - What actions could services take, and which intervention elements could services implement to reduce barriers and support the integration of tailored PA interventions? What may these actions lead to?									
Category	Service provision					Service processes			Service-led barrier reduction	
Sub-category	Service access	PA facilitators	Tailored PA	Engagement aid	Decision aid	Progress checking	Integrating choice	Information sharing	Mental health	Behavioural consequence
Code	Organisational support (e.g. scheduling) (1) Access by cooperation (1) Access by proximity (1)	Psychological support (3)/integrated PA (2) Low-cost PA (1) Informative education (2) (e.g., on PA benefits, on PA/SU interaction) Gradual PA increase (1) Expert availability (1) Goal-setting (1) PA variety Organisational support (1)	Feeling of appreciation (2) (e.g., feeling cared for) Less competitive (1) Allows individual feedback (1) Feeling valued (1) Engagement (2)/ motivation increase (1)	Reward system (1) Positive testimonies (2) Behavioural domino effect (x2) Social encouragement (1) Social connection (2) Informative education (to help PA integration) (1)	Informative education (2) (e.g., personal treatment benefits) PA variety (2) Available options (1) Local connection (1) A run through (1)	"More eyes are better" (3)	Screening procedure (1) Universal model (1) Increased resources (1) PA variety (1) At the start (2) Continuously (1) Where appropriate (1)	Entire treatment team (3) Where appropriate (1)	Feeling of appreciation (1) (e.g., feeling valued) Positive feeling (2) (e.g., less worry)	Engagement increase (1) Motivation increase (1) Value increase (1)

Note. Encased numbers indicate numbers of code citation "(1)"

4.6 Interpretative (Mixed Methods) Discussion

4.6.1 Integration of quantitative and qualitative results: A comparison

Both the quantitative survey and qualitative focus group data indicated a high rate of treatment acceptability of physical activity interventions among young people with problematic substance use and a strong willingness to engage in such interventions. One potential explanation for the positive perception of PA interventions may be the self-selection of participants into the study, as well as the large number of benefits they perceived to be associated with PA participation and high level of engagement in PA.

Similar overarching themes were identified in the reported benefits of PA as assessed in the quantitative survey and qualitative focus group. Both outlined mental health benefits (e.g., decreased stress, improved mood), behavioural benefits (e.g., improved functioning, increase in other health behaviours), and social benefits (e.g., social encouragement and connection). However, while quantitative results further highlighted significant physiological benefits of PA including improved fitness (e.g., increased stamina, endurance, and body image), these benefits were not identified within the qualitative study. One explanation for the increased focus on body-related benefits (e.g., body image) within the quantitative study may be a decreased risk of response bias in anonymous surveys (Epperson & Peck, 1977; Furnham, 1986). In intimate settings such as focus groups, however, a strong focus on body-related benefits such as body look, physical silhouette and fitness may potentially cause fear of other participants' judgement and, thus, response bias due to the lack of anonymity. No existing research was found to support this theory. The focus group data, in turn, highlighted the benefits of PA for life structure, including providing a regular routine and direction in life. One potential explanation of the different responses recorded in quantitative and qualitative data may lie in the pre-determined and fixed structure of the online survey compared to the flexible nature of the focus group, which facilitated the exploration of themes beyond the pre-determined structure.

The mental health needs of young people with problematic substance use were addressed in both the quantitative and qualitative datasets. Quantitative analyses showed significant relationships between mental health and PA participation and experienced barriers to PA and PA interventions. Young people reporting more severe mental health concerns were more likely to experience barriers to PA and to participate in less PA than

young people reporting better mental health. Young people participating in more physical activity in turn were more likely to report better mental health. Similarly, focus group participants highlighted the potential of physical activity to improve mood and decrease depression symptoms, however, stressed the necessity of receiving additional psychological support as well. The findings call attention to the potentially bidirectional relationship of physical activity and mental health, and the importance of addressing mental health concerns in young people to increase the likelihood of participating in PA interventions but also the potential of improving young people's mental health through facilitating simple and achievable PA plans (P. Ekkekakis & Murri, 2017).

Perceived barriers to PA participation differed between survey results and focus group findings. While quantitative results predominantly indicated time and physical exertion to be overarching barriers, qualitative results highlighted substance use related barriers to PA. Further, qualitative data outlined additional barriers relating to health services (e.g., vague PA recommendations provided by clinicians). Notably, both datasets identified significant social barriers to PA, with quantitative data describing a lack of social support for PA participation and qualitative data emphasising cultural barriers, gender barriers, or negative group dynamics. Similar to the differences found in perceived PA benefits, the differences in barriers may also be explained by the limited ability of the quantitative survey to explore barriers beyond pre-determined answers in the included survey measures.

4.6.2 Mapping findings to COM-B and CFIR

In line with the COM-B model of behaviour change and the Consolidated Framework of Implementation Research (CFIR), several behavioural factors or domains are essential to achieve behaviour change in young people, as well as to allow an intervention to yield an effect and be implemented successfully (Robert West & Michie, 2020a). The COM-B model and CFIR overlap on three domains, i.e., opportunity, capacity and motivation. The fourth domain of the COM-B addresses the target 'behaviour', while the CFIR describes a different domain, 'need', as essential to changing behaviour and implementing an intervention.

Notably, these constructs may refer to both facilitators (non-research staff who are trained in intervention facilitation) of an intervention and the affected individuals who are the focus of an intervention. For instance, the domains may explore these dimensions in relation to facilitators' behaviours that need to change to implement an intervention successfully. The domains may also refer to factors contributing to affected young people's

behaviour change as part of a successful intervention. In line with the focus of this thesis, however, the model has only been applied to the perspectives of young people.

To investigate how young people's experiences may impact behaviour change and effective implementation of (tailored) PA interventions into substance use treatment practice, the reported barriers, benefits, and service needs which were identified as part of the quantitative and qualitative data collection were mapped onto the COM-B and CFIR domains (see Table 16). This allowed an exploration of how the barriers may align with the domains that are relevant to achieving behaviour change. It further showed how benefits of PA and PA interventions may potentially improve the likelihood of behaviour change by positively impacting opportunity, capability, and motivation regarding PA participation of young people.

As the described domains interact with each other, changes, or improvements in one domain may lead to changes in other domains. For instance, increased opportunity and capability may lead to an increase in motivation. Further, both capability and opportunity seem to strengthen the relationship between motivation and target behaviour, i.e., increased physical activity and decreased substance use (Robert West & Michie, 2020a). The interaction between all four domains, in turn, may create positive feedback cycles between behaviour change and opportunity, capability and motivation (Robert West & Michie, 2020a). According to the COM-B model, active reduction of existing barriers and thus increased opportunity, capability and motivation of young people may lead to behaviour change (i.e. increased PA), which again may positively feed back into the individual domains and induce further increases. Consequently, behaviour change may increase and get easier with time. Similarly, focusing on essential service needs, as identified by young people, may also decrease barriers in all domains.

Table 16

Mapping of qualitative service needs, and quantitative and qualitative barriers/benefits to PA onto COM-B and CFIR

CFIR constructs	Construct descriptions (Damschroder et al., 2022)	PA/ PA intervention benefits	Barriers to PA/PA intervention	Service needs
Need	The individual(s) has deficits related to survival, well-being, or personal fulfilment, which will be addressed by implementation and/or delivery of the innovation.	Intervention Reduces substance use Increases overall well-being Increases life span Increases mental health	Substance use	
Capability (COM-B dimension)	The individual has interpersonal competence, knowledge, and skills to fulfil the role.	Physical capability Increased physical health/wellbeing/energy Increased stamina/fitness Improved behaviour Improved sleep Social capability Increased social skills Psychological capability Knowledge on PA benefits Improved mental health Empowerment Increased self-efficacy	Limited knowledge on PA and substance use Tiring, fatiguing SU related barriers Mental illness	Tailored PA Behaviour change interventions Informative education on PA and SU Continuous progress checking Decision aids Engagement aids Combination of psychological and PA support Supervision according to treatment stage

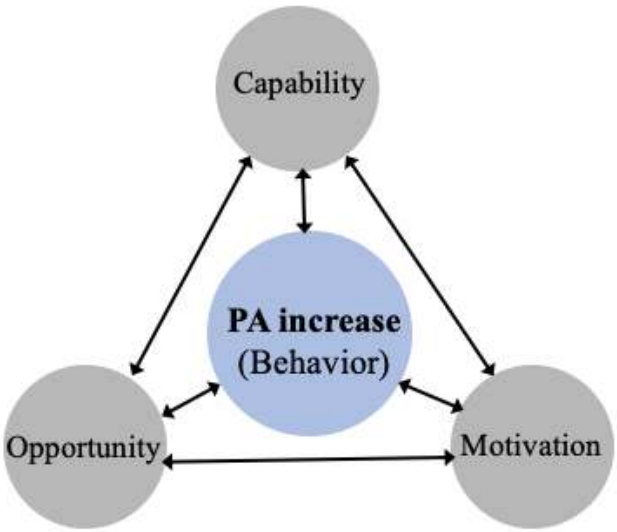
CFIR constructs	Construct descriptions (Damschroder et al., 2022)	PA/ PA intervention benefits	Barriers to PA/PA intervention	Service needs
Opportunity (COM-B dimension)	The individual has availability, scope, and power to fulfil the role. (i.e., factors that lie outside of an individual; Michie, Van Stralen, et al., 2011)	Life structure Increased social connection (social opportunity)	Limited access Limited financial resources/equipment etc Limited social opportunity (cultural restrictions, social stigma) Not enough time Logistical barriers Service-induced barriers	Increased service access Local connection Service-led barrier reduction
Motivation (COM-B dimension)	The individual is committed to fulfilling the role.	Habit forming Enjoyment Entertainment Motivation increase	Lack of motivation Substance use (affects motivation) Partner/family discouragement Hard work	Motivating/ passionate clinician Integrating choice

The mapping highlights potential areas of intervention and improvement from a service perspective, particularly relating to barriers and service needs on the capability and opportunity domains, as well as service needs on the motivation domain. Interventions in these domains may positively affect other associated dimensions through positive feedback loops and consequently increase the likelihood of behaviour change.

According to COM-B behaviour change theory, improvement in the three domains of motivation, opportunity and capability leads to an increase in PA and PA intervention participation (see Figure 9), which may, in turn, reduce substance use in young people. Improvement may refer to either a reduction of barriers on the domains, facilitation of service needs or an increase in benefits on the domains. An increase in perceived benefits on the different domains, in turn, may result from either increased PA behaviour through the previously described positive feedback loops or be a direct consequence of barrier reduction and facilitation of service needs. For instance, young people's improved well-being in the capability domain may be a consequence of increased PA behaviour or may be triggered by a service's active barriers reduction or facilitation of service needs, which may lead to feelings of being valued and consequently increased well-being as reported during the focus group.

Figure 9

Interaction of the COM-B factors (Michie, Van Stralen, et al., 2011)



The integration of qualitative and quantitative findings (see Table 12) and their mapping onto the COM-B behaviour change model and CFIR highlights the complexity of the multiple changes required across domains to increase the effectiveness of PA interventions in leading to the desired outcomes, i.e. behaviour change. It further outlines potential points of intervention to implement practice changes for services that could improve PA access for young people with problematic substance use, decrease barriers, and increase PA benefits to support the occurrence of the target behaviour (increased PA behaviour, substance use reduction). Last, the integration calls attention to the unique service needs of young people that must be considered regarding PA participation and PA interventions.

4.7 Phase 2 Discussion

Phase 2 investigated young people's perspectives regarding the integration of PA interventions into treatment practice. Young people's substance use, willingness to engage with clinical services, mental health, current physical activity participation, perceived barriers and benefits to physical activity, and acceptability of physical activity interventions were assessed using a quantitative online survey. A subsequently conducted qualitative focus group explored young people's experienced barriers to PA and PA interventions, intervention preferences, and services needs in more depth.

Overall, quantitative findings showed a high acceptability of PA interventions in the investigated population of young people with problematic substance use if offered integrated with existing substance use treatment. Young people perceived PA interventions to be appropriate and effective in reducing problematic substance use. Quantitative findings further revealed significant relationships between young people's mental health, physical activity participation and PA barriers: Better mental health and more frequent participation in PA were associated with lower perception of PA barriers. Low perception of PA barrier in turn was associated with increased treatment acceptability.

Notably, no relationship between substance use risk level (moderate, severe) or substance type and treatment acceptability, physical activity participation or experienced barriers was found (quantitative findings), suggesting that the extent of young people's substance use may not be a sufficient indicator for a young person's acceptability of the intervention. Instead, young people's mental health, experienced PA barriers and current PA

participation (sufficient/not sufficient), despite problematic substance use, may be a more suitable indicator for treatment acceptability and initiation. Another explanation for the absence of a relationship may be the limited variability in substance use problems, which was caused by an exclusion of young people with low substance-related risk and inclusion of young people with strong treatment indication only (i.e., at moderate/ severe substance-related risk).

The qualitative data predominantly confirmed and complemented the quantitative data by shedding light on the experiences of young people with problematic substance use. In addition to perceived benefits and experienced PA barriers, young people expressed hopes and wishes, expectations, but also current and past struggles regarding substance use and physical activity participation. While many of these perspectives differed among the participating young people, the focus group also revealed shared preferences and provided a description of what such integrated intervention could be according to young people.

A large number of qualitative codes (i.e., young people's insights) relating to social connection and behavioural domino effects (i.e., an increase in one health behaviour such as PA participation leads to increases in other health behaviour such as healthy eating) suggest that affected young people may experience a range of other co-occurring issues, such as unhealthy eating and social isolation. Particularly, feelings of loneliness in people with problematic substance use have been found in previous research (Hosseinbor, Yassini Ardekani, Bakhshani, & Bakhshani, 2014). It is thus not surprising that young people in the current study described a preference for physical activity interventions designed to help with a range of concerns beyond substance use. Further, young people's perception that PA interventions have the potential to help with a range of different concerns beyond substance use may be associated with the high levels of acceptability of PA interventions found in this study.

While young people also described various experienced barriers to physical activity, physical activity intervention and substance use treatment access, the most frequently cited barriers remained substance use. This barrier was described in detail, with young people's finances (e.g., poor financial management and predominant allocation of financial resources to substance use) and motivation (e.g., low motivation) being predominantly affected.

The supervision format preferred appeared to be related to a young person's progression through treatment. Supervised physical activity was favoured early on within an

intervention, when habits had yet to be established, compared to unsupervised physical activity, which was preferred at a later point in treatment. Despite a preference for supervised PA, most young people still preferred planned physical activity sessions, which aligns with an expressed need for organisational support during the focus group session. This need may imply that young people are experiencing difficulties with organising and scheduling physical activity sessions, increasing the risk of disengagement.

There was a clear preference for individual physical activity sessions compared to group sessions. Nevertheless, young people also expressed a need for social connection and social encouragement in several other categories and themes that were identified as part of the qualitative content analysis. For instance, young people described positive experiences of being motivated by others, hearing other people's positive testimonies, and being integrated into a social network of people participating in the same intervention. One explanation for this discrepancy may be a general need for adaptable and flexible physical activity interventions, which allow either social connection or solitude where relevant.

Several suggestions for health providers were identified by young people, including the need to provide informative education on physical activity benefits for substance use outcomes (both personal and long-term) and clear physical activity recommendations. A respective clinician's education and training in physical activity facilitation was described as secondary to their passion for physical activity, which was considered to be a critical factor.

Peer support as part of PA interventions was described as potentially beneficial, yet possibly irrelevant, and was thus preferred as an optional addition by young people. These findings align with recent research which argues that the effect of peer support varies across different service types. While it seems to be effective in some contexts, it seems to show only little effect in others (Shalaby & Agyapong, 2020).

Finally, experienced barriers, benefits, facilitators and needs of young people were drawn together and integrated within the Consolidated Framework of Implementation Research and COM-B model of behaviour change. The integration highlights how active reduction of experienced barriers and increased perception of PA benefits may increase young people's opportunity, capability and motivation to engage in PA and PA interventions, which in turn are elements that contribute to the successful implementation and, consequently, the success of an intervention according to the CFIR.

4.7.1 Previous literature on PA barriers, benefits, and preferences

Physical activity interventions as part of mental health treatment are perceived as acceptable by young people (Parker et al., 2021). However, the acceptability of PA interventions in young people with problematic substance use has not been sufficiently investigated in previous research. One study reported high acceptability of PA interventions for cannabis reduction in young people (Bonar et al., 2023). This is in line with the current findings, which reported high acceptability of physical activity interventions in young people. Notably, a correlation between high levels of acceptability and general interest in physical activity and the self-selection of young people for the current research project can be assumed.

Barriers and facilitators to PA in existing literature were predominantly reported for young people in general; however, rarely assessed for young people with problematic substance use. Consequently, caution is needed in comparing current and previous research findings because of the unique barriers that young people with problematic substance use might experience. Despite this, barriers to physical activity participation as reported in Phase 2 aligned with previous findings, which report gender barriers, cultural barriers, an unsupportive environment (i.e., family, partner), lack of motivation, lack of access, time and financial factors, social competition, inappropriate activities (inappropriate treatment models), a lack of knowledge on PA benefits, competing interests and self-consciousness about appearance (unattractive exercise clothes) (Daskapan, Tuzun, & Eker, 2006; Othman et al., 2022; R Rees et al., 2001; R. Rees et al., 2006; Sabharwal & Sabharwal, 2018). Young people participating in Phase 2 additionally reported substance use (and related financial factors) as significant barriers.

Findings on barriers were also consistent with Ashton, Hutchesson, Rollo, Morgan, and Collins (2017), who identified motivation, time and cost as the most prominent barriers to PA in young Australians, and a review conducted by Martins et al. (2021), which identified exhaustion, tiredness, competition, lack of choice, lack of time, unsupportive environment (i.e., lack of support from friends, family), lack of motivation, low self-efficacy, lack of choice, cultural norms, and no time for other responsibilities as strong barriers among the age group 13-18 years. Further, a decrease in PA competence with age was reported in young people (Martins et al., 2021), which may explain the need for clear directions and instructions identified in this research project.

Benefits and facilitators of PA reported in previous research and Phase 2 of this research included variety in activities, tailored PA, facilitation of social connection, encouraging environment (e.g., family/friends), improved wellbeing, enjoyment, sense of achievement, and diverse activities (Martins et al., 2021; Othman et al., 2022; R. Rees et al., 2006). Notably, previous and current findings were similar in their emphasis on the importance of social aspects of PA as reported by young people. R. Rees et al. (2006) and Martins et al. (2021) further point out that enthusiastic facilitating staff who emphasise the fun aspect of physical activity may promote physical activity participation in young people. This compares favourably to qualitative findings of the focus group in which young people expressed a clear preference for PA facilitators who are passionate and motivated about physical activity and can transfer this passion (and fun) onto young people.

A noteworthy difference in current and previous research findings was the strong focus on mental health and substance use benefits reported by young people with problematic substance use. The explicit reporting of mental health benefits may be explained by the high comorbidity of substance use and mental disorder, which highlights the importance of experiencing mental health benefits in this population (Elliott, Huizinga, & Menard, 1989; McGorry et al., 2007).

While young people participating in the current project reported a clear preference for tailored PA and having choice within the activity selection process, existing research describes choice as both a barrier and facilitator to PA (Martins et al., 2021). One explanation for this difference may be the confounding variable "competence in PA", which may have a mediating effect on perception of choice. Young people with strong feelings of self-efficacy and competence may appreciate having a choice in PA selection, while YP lacking in self-efficacy and competence may be overwhelmed by having a choice and thus experience it as a barrier (Martins et al., 2021). These nuances in young people's preferences and experiences when it comes to PA participation clearly demonstrate that there is no "one size fits all" in terms of interventions. Consequently, both existing and current research correspond in their recommendation for highly tailored and personalised interventions which allow for young people's unique needs to be addressed.

4.7.1.1 Barriers, facilitators and preferences in PA interventions

Barriers, benefits, and preferences to partaking in PA interventions for substance use reduction in adults were examined in a recent review, which showed strong alignment of

implications for practice with the current research project. Similar to the findings from Phase 2, the review highlighted the importance of tailoring the intervention format to a client's progression through treatment. Namely, young people may benefit from supervised, group-based PA at the start of an intervention to support the development of habits, provide shared accountability and counter the effects of substance-related social isolation. Once habits have been established and psychological support has been provided, young people may benefit from unsupervised, individual PA to strengthen self-efficacy and facilitate more flexibility. The review further identified comparable intervention needs in adults who use substances, including additional scheduling help, reminders, and integrated interventions that simultaneously address a variety of concerns, including mental health and substance use (Horrell et al., 2020).

4.7.2 Phase 2 Limitations

Several limitations to the research need to be considered. First, the lack of a control group allowed no comparisons beyond the population of interest. This was due to the skip logic applied within the quantitative survey, which prevented ineligible individuals from completing the survey or providing additional data. The inclusion of a control group should be considered for future research to investigate factors related to treatment acceptability.

A second limitation refers to the self-selection bias, i.e., participants' self-selection to participate in the study or not, which likely biased the sample into young people being more likely to perceive PA favourably. For instance, the high rates of treatment acceptability of physical activity interventions and high total average rates of PA engagement found in the current study may be explained by the participation of young people who are interested in physical activity and/or value treatment for mental health and substance use issues and are thus more likely to express greater acceptance towards physical activity interventions. Further, while research has shown an overall greater prevalence of substance use and substance use disorders in males (Chen & Jacobson, 2012; McHugh, Votaw, Sugarman, & Greenfield, 2018), the participant population in this study was predominantly female, which was possibly caused by systematic gender differences in online survey participation favouring female self-selection (Becker, 2022).

A third limitation refers to the size of the qualitative focus group (N=4). While the group size was in line with recommendations for complex and sensitive topics (Richard A. Krueger & Casey, 2015), the findings need to be interpreted with caution. Research

including a larger group of young people may provide more insights into unique and the nuanced experiences of young people with problematic substance use.

A fourth limitations refers to the perceived treatment acceptability as reported by young people with problematic substance use. While findings overall indicated good, theoretical acceptability, it is unclear if the high levels of acceptability translate into treatment engagement.

Lastly, the available data included numerous outliers and highly skewed distributions, which are common for substance use populations (Field, 2017; Wagner et al., 2015). While these characteristics represented the richness and diversity of the dataset on one side, they also precipitated several challenges for data analyses, such as limited nonparametric methods.

4.8 Chapter Summary

Chapter 4 provided quantitative insights into correlates of treatment acceptability, young people's substance use, mental health and physical activity participation, as well as qualitative insights into experienced barriers to PA and PA interventions, benefits and facilitators of PA, and intervention needs as identified by young people. The chapter further mixed quantitative and qualitative findings, integrating them into the CFIR and COM-B model and highlighted opportunities for intervention where young people's capability, opportunity, and motivation to change substance use behaviour could be increased.

The following *Chapter 5. Discussion and Recommendations* draws together findings from Phase 1 (i.e., existing evidence) and Phase 2 (i.e., young people's expertise) to discuss the clinical implications of the findings, highlight the importance of integrating a youth voice into research and provide recommendations for clinical practice and future research. Chapter 5 finishes by concluding and summarising the studies included in this program of research.

PHASE 3- RECOMMENDATIONS

5 Chapter: Discussion and Recommendations

5.1 Chapter Introduction

Chapter 5 draws together findings from the available intervention evidence (Phase 1) and young people's expertise (Phase 2) to evaluate the clinical implications of the findings and provide preliminary recommendations for clinical practice and research. By doing so the chapter draws together two essential aspects of evidence-based practice, existing research evidence and affected individuals' perspectives, and thus informs intervention development and best practice in this treatment area. The chapter additionally discusses shortcomings in both the existing evidence-base and the current program of research. The chapter concludes with discussing the importance of building research collaborations with young people and integrating a youth voice.

5.2 Discussion

The studies reported in this thesis established the depth, breadth, and limitations of the existing evidence on physical activity interventions for addressing problematic substance use in young people aged 12-25 years. While some promising evidence exists, the limitations of existing research and sometimes divergent findings impede drawing clear inferences. Additionally, the community context of the findings needs to be considered; it is unclear if findings are generalisable to a clinical context.

Overall, the existing evidence (as investigated in Phase 1) describes a potentially promising effect of PA interventions of various formats, i.e., short-term interventions and comprehensive long-term interventions, on substance use outcomes such as cravings and substance use frequency in young people aged 12-25. Existing studies tended to focus on tobacco use outcomes in young people, with limited investigations of other substance types, including cannabis, stimulants, psychedelics and opioids. There is thus insufficient evidence to support the claim that PA interventions effectively improves substance use outcomes apart from tobacco use. Additionally, the large heterogeneity among existing research regarding physical activity type and duration, as well as the large variety of measurement tools applied,

hinder recommendations as to what intensity or duration of physical activity may be beneficial for different substance types or if intensity, duration, and type of PA are relevant in this cohort to achieve mental health and substance use benefits.

For alcohol use outcomes, four studies identified in Phase 1 reported a significant effect of PA interventions on alcohol consumption in young people, in that intervention participation improved alcohol outcomes. However, international research has previously reported an ambiguous positive relationship between alcohol consumption and physical activity (Niedermeier, Fruhauf, Kopp-Wilfling, Rumpold, & Kopp, 2018; Piazza-Gardner & Barry, 2012); that is, increased physical activity participation is associated with increased alcohol consumption. Given these inconsistent findings more research into confounding factors, such as the impact of intervention setting on the relationship between PA and alcohol use, is needed.

Despite the overall limited available evidence, the potential effects of PA interventions on substance use in young people warrants a call for more research to investigate the outcomes of integrating PA interventions into standard substance use treatment for young people.

Physical activity interventions are further perceived as highly acceptable and suitable for substance use reduction in young people aged 16-25 years with problematic substance use. However, the perceived suitability is limited to PA interventions being integrated with standard substance use treatment, i.e., physical activity is described as a potential additional benefit (i.e., "bonus") beyond regular treatment, which may further promote the improvement of other health behaviours, including increasing social interaction and a healthy diet. This indicates that young people with problematic substance use may apply a holistic view to treatment.

The heterogeneous nature of results, visible in a large number of preferences for PA, service needs and (substance- and non-substance-related) experienced barriers described by young people, highlight the importance of tailored interventions, which are adapted and personalised to each young person's level of complexity and needs. Tailoring may include the facilitation of individual versus group-based PA depending on a young person's need for social connection or motivational support, facilitation of PA at different intensities depending on a young person's PA competency and fitness level, or facilitation of supervised versus unsupervised interventions depending on a young person's symptom presentation and

particular needs while progressing with their treatment. Most importantly, young people expressed a clear preference to be involved in decisions regarding their treatment, particularly PA treatment decisions.

The complexity of young people's individual needs is further evident in the quantitative findings, which indicate that there may be substantial differences regarding young people's capability to participate in PA interventions if integrated into existing treatment services. For instance, the latent class analysis indicated the presence of two different subgroups of young people; one reported better mental health and lower perception of physical activity barriers, while the second reported a higher likelihood of experiencing severe mental health concerns and heightened perception of PA barriers. With barriers to PA being significantly associated with treatment acceptability of PA interventions (see chapter *4.4.4.2 Relationship analyses*), the latter group may differ in their capability to participate in an integrated PA intervention and may likely require either more comprehensive support for their mental health needs or benefit from a straightforward, achievable PA plan to improve their mental health first.

5.2.1 Clinical implications

Several clinical implications can be drawn from findings in Phase 1 (Existing Evidence) and Phase 2 (Young People's Expertise), which may contribute to the integration of PA interventions into treatment practice for young people with problematic substance use. These implications include the potential for more informed decisions regarding a young person's capability to participate in a PA intervention for substance use reduction, as well as providing clinicians with a more streamlined and guided process to identify areas of intervention more effectively to improve PA in young people. Notably, these implications need to be interpreted in light of the equivocal evidence outlined in chapter *5.2 Discussion*; the uncertainty of evidence will be discussed in more detail in chapter *5.2.3 Limitations*, which indicates that PA interventions may not be appropriate for all young people with problematic substance use.

5.2.1.1 Assessing capability to participate in PA interventions

The outcomes reported in chapter *4.4.4.4. Data mining and modelling*, particularly findings on latent classes among young people and decision tree analysis, may facilitate improved and more streamlined decision-making by clinicians regarding a young person's capability

to engage with a PA intervention integrated with their regular treatment. Capability was defined as a young person's psychological and physical capacity to engage in a physical activity intervention according to the COM-B behaviour change model (see chapter *1.6.5 COM-B model of behaviour change*).

The latent class analysis indicated the presence of two different groups of young people, with one class indicating higher capability to engage than the second group. The former group included young people reporting better mental health, a higher likelihood to participate in sufficient PA, lower substance use risk, lower perception of barriers to PA and higher treatment acceptability. The second group included young people with severe psychological distress indicating severe mental health concerns, heightened perceptions of PA barriers and high substance use risk levels (indicating likely substance dependence). Exploration of these factors (i.e., barriers to PA, current PA participation) as part of the psychosocial intake assessment into a service and clinicians' awareness of the different experiences of and attitudes towards PA participation that young people may have, can provide clinicians with essential information on the suitable treatment sequence for a young person. While some young people may demonstrate capability to participate in an integrated PA intervention (group 1), other young people may benefit from receiving psychoeducation an/or guidance on how to make small changes initially (group 2). Notably, as previously described, there is a strong indication for PA interventions to be integrated with standard treatment due to potential additional benefits for substance use reduction rather than as replacement or substitute intervention.

The decision tree analysis and generalised additive modelling indicated that perceived PA barriers are lowest in young people reporting better mental health and sufficient PA participation. With barrier perception being significantly associated with treatment acceptability (and barriers perception being used as an indicator of treatment acceptability), these findings indicate that young people engaging in sufficient PA with no indication of severe mental health disorder are experiencing the fewest barriers to PA participation and are thus likely expressing highest capability to participate. Young people reporting more complex symptom presentations, in turn, including insufficient PA levels or severe mental health concerns, may need much more additional psychosocial support or guidance on straightforward, achievable PA first to increase their psychological (e.g. improved mental health) and physical capability to participate. Once again, the findings may provide clinicians with essential information regarding clients' capability to participate in

PA interventions and thus inform clinician's decision-making regarding the sequence in which complex needs are addressed.

5.2.1.2 Strategic support localisation for PA participation

The quantitative and qualitative findings outlined in *Chapter 4. Young People's Expertise: A Mixed Methods Exploration* provided insights into the complex and multidimensional experiences of young people with problematic substance use regarding PA participation, particularly into the large number of experienced barriers to PA and potential supportive service needs required.

The mixed methods integration of these findings according to the COM-B model and alignment with the CFIR framework (see *4.6.2 Strategic alignment of service needs, barriers/benefits to PA onto COM-B and CFIR*) provides clinicians and service managers with a tool to streamline localisation of support needed to increase young people's opportunity, capability and motivation to elicit behaviour change and increase PA participation. This is of relevance to young people, indicating more capability than others, as described in the previous chapter.

The mapping provided in Table 16 allows clinicians and service managers to assess young people's barriers, service needs and potential benefits on different (COM-B) dimensions and identify likely accumulations of barriers or service needs restricting young people's opportunity, capability and motivation. It further provides clinicians with essential information on "priority areas" regarding PA participation, with dimensions showing a large accumulation of barriers likely needing to be attended to first. The service needs, in turn, as aligned with the different dimensions, provide clinicians with potential steps to be undertaken to improve the respective dimension. For instance, a young person may be experiencing particular barriers limiting their capability, including limited knowledge of the benefits of PA for substance use reduction, low mood/low mental well-being and the tiring nature of PA. Particular service needs that could address these barriers on the capability dimension may include providing informative education on the benefits of PA for substance use reduction, combined psychological support with integrated PA intervention to improve well-being and tailored PA in line with a young person's energy levels. These service steps, in turn, may increase a young person's capability and consequently elicit benefits on this dimension, including increased fitness, physical health and improved mental health.

Increased capability again may positively affect young people's opportunity and motivation through positive feedback loops.

5.2.2 Implementation of PA interventions

In line with the research interest, i.e., the integration of PA interventions into treatment practice for young people with problematic substance use, the CFIR was used as a guiding framework. According to the CFIR, several domains including numerous constructs are essential to the successful integration and implementation of PA interventions into treatment practice for young people (see chapter *1.6.4 Consolidated Framework of Implementation Research*). Due to budgetary and time constraints, this project only explored a few of these constructs predominantly within the two domains 'Individuals' and 'Innovation'.

For the Innovation domain, several key barriers were identified that impact the integration of PA interventions into practice, including the limited knowledge of several context factors such as *Innovation cost* or *Innovation source.* Further, the existing literature does not currently provide robust evidence supporting the apparent effectiveness of PA interventions nor sufficient information regarding the relative advantage of PA interventions over other integrated interventions.

For the Individuals domain, young people provided valuable insights into several constructs, including barriers experienced in their capability, opportunity, and motivation to engage in a PA intervention. However, the domain also addresses several other constructs that are essential to successful implementation, such as implementation facilitators and leaders within a health service. These constructs, as well as the *Outer Setting* (e.g., local conditions, critical incidents, financing, policies & law) and *Inner Setting* domain (e.g., structural characteristics, relational connections, etc.) were not investigated in this research project and appear to have been under researched within the existing evidence base.

Based on the insufficient information within the investigated CFIR domains and the limited knowledge of numerous other essential domains, successful implementation of a comprehensive PA intervention in Australian health services would likely require a comprehensive effectiveness-implementation approach (see also Curran et al., 2012).

5.2.2.1 Single element integration

The findings of this research project suggest potential for the integration of simple PA-promoting elements to reduce barriers to PA participation and increase PA capability,

motivation and opportunity for young people. Integrating simple elements, for instance, integrating brief psychoeducation on the benefits of PA for substance use reduction as part of treatment sessions, would not require a comprehensive assessment of contextual information as highlighted in the CFIR, such as assessment of available resources (e.g., funding), structural characteristics (e.g. infrastructure components) or local attitudes and local conditions. Integration of single, simple elements could thus circumvent the issue of missing essential information on several domains that are essential to implementing comprehensive PA interventions according to the CFIR. Such an approach would further imply that integrated elements would automatically be adaptable, not complex and easily triable. For instance, elements that could be integrated into current practice include providing a scheduling aid for PA participation (e.g., in individual consultation sessions), providing informative education on the benefits of PA for substance use reduction and mental health, or continuous progress checking during a client's regular check-ins. As demonstrated earlier in this research project (see also chapter 3.4 Impact of BCT on PA Interventions: Publication 2) there may be opportunity to integrate BCT as part of treatment, which would not require extensive clinician training and support. With limited information on several CFIR domains that are essential to the successful implementation of PA interventions, the integration of single elements into present practice may hold potential for an interim solution, yet may not act as a substitute to research, which is essentially needed in this area.

5.2.3 Limitations to this research project

Several limitations to the research exist, which need to be carefully considered regarding the integration of PA interventions as part of clinical practice for young people with problematic substance use. These limitations include the uncertainty and heterogeneity of the existing research evidence and the changing patterns of young people's substance use.

First, the existing evidence described in Phase 1 of this thesis highlights the existence of a limited evidence-base for PA interventions for young people with problematic substance use, as well as outlines the uncertainty and the overall low quality of existing evidence. The heterogeneous nature of study designs, intervention designs (including different intervention durations and formats), and measurement tools used to assess investigated substance use outcomes impede the comparability among different interventions. Consequently, existing reviews on PA interventions for substance use reduction in young people (see also Linke & Ussher, 2015; Simonton et al., 2018; Thompson et al., 2020), including the systematic

review conducted in Phase 1 of this research (Klamert, Bedi, et al., 2023) were not able to synthesise intervention effects in meta-analyses. Additionally, many existing studies describe comprehensive multi-component and multi-modality interventions (see also, *Chapter 3. Existing Evidence: Systematic Review and Meta-Analysis*); it is thus not clear if the positive effects on substance use outcomes is a consequence of the PA component or may instead be generated by a combination of variables as PA and psychological support. Overall, 61% of studies identified in Phase 1 (Chapter 3) reported a significant effect of PA interventions on substance use outcomes. However, it is unclear if these effects can be solely attributed to the PA components of interventions. Consequently, there is not enough available evidence to demonstrate the effect of PA interventions on substance use across a range of substances in young people. Instead, it is only possible to highlight the potential beneficial effect of these interventions for young people with problematic substance use. Further, many intervention studies omit essential details on study design or data collection or don't describe outcomes in appropriate detail to ensure the reproducibility of the research. More research is needed to investigate these effects further, including studies investigating the effect of PA interventions on specific substance types, studies comparing the effect of PA interventions with other intervention modalities, and large scale studies investigating maintenance of the effects of PA interventions.

A second limitation is lack of research on substances other than on tobacco use (cigarette smoking). Other publications in Phase 1 commonly referred to "substance use" overall without any clear indication as to which substances were investigated. Consequently, no conclusions can be drawn regarding the effect of PA interventions on other substance types, including alcohol, cannabis, stimulants, hallucinogens, or opioids. Additionally, with changes in global tobacco use patterns in recent years, including a rapid increase in e-cigarette use and vaping among young people (Sun et al., 2021; Wakefield, Haynes, Tabbakh, Scollo, & Durkin, 2023), it is unclear if previous findings regarding the effect of PA interventions on tobacco use outcomes in young people will be applicable to the current use pattern. Many outcomes related to vaping and e-cigarette use in young people are still poorly understood, thus, new research would be needed to replicate and confirm previous findings that were predominantly demonstrated in cigarette use.

A third limitation refers to the subjective nature of data in Phase 2, which was based on self-report measures and a qualitative focus group interview. Self-report measures have been criticised due to the inherent threats to validity limiting any inferences that can be

drawn (Chan, 2008). Particularly for physical activity measures, previous research has indicated only low agreement between objective PA measures and self-reported PA (Steene-Johannessen et al., 2016), as well as an inability of self-report measures to quantify PA accurately (Mâsse & de Niet, 2012).

Despite these concerns, self-report measures continue to be widely accepted for use in health research (Chan, 2008) and may not exclude a factual effect. It is argued that self-report measures are not inherently flawed, but their accuracy depends on a variety of contextual factors (Chan, 2008; Del Boca & Noll, 2000). Affected individual's self-reported insights are further foundational to developing evidence-based treatment and informing best practice (Rubin, 2008). Given the inherent benefits of using self-report measures in human research, these benefits were judged to outweigh validity concerns.

A final limitation is the lack of integration of clinician's expertise as part of the research project due to the significant impact of COVID-19 disruptions to Victoria's health system, recognised as one of the most significant disruptions globally, as Melbourne, Victoria entered a 'state of emergency' for periods of several months at a time (Cheek et al., 2021). Clinician expertise is an essential component of evidence-based medicine, which describes the process of clinical decision-making based on the currently available best evidence within a field. Evidence-based medicine integrates client values and preferences with clinician expertise and the best available research evidence to provide clients with the (currently) best possible care (Masic, Miokovic, & Muhamedagic, 2008; Rubin, 2008). This avoids over-reliance on either of these three knowledge streams and addressing the common deviation between the subjectively expressed preferences of individuals and expert-led opinions on effective treatment strategies.

5.3 Recommendations

5.3.1 Importance of youth voice

Equal participation of young people in decisions regarding their treatment, as well as a mutually respectful clinician-client relationship, is highly recommended to enhance treatment outcomes and increase young people's participation in PA interventions (see also, chapter *2.6.2 Participatory research with youth*). Integration of young people's perspectives, as well as giving young people choices regarding their own (PA) treatment, were key findings from the focus group in Phase 2, during which young people described a positive

relationship between having choices and a voice within their treatment with increased feelings of being valued and appreciated by a health service. While young people have reported low motivation to enter substance use treatment previously (Battjes, Gordon, O'Grady, Kinlock, & Carswell, 2003), choice, respect and shared decision-making can positively impact treatment outcomes and increase participation with a treatment or intervention (Dunne, Bishop, Avery, & Darcy, 2017; Laugharne & Priebe, 2006; McWhirter, 2008; Pullmann et al., 2013).

The importance of having choice as part of treatment decisions, particularly choice in the selection of physical activities in which a young person participates, was expressed numerous times during the qualitative focus group. The impact of perceived choice on treatment participation and outcomes was previously described by Catalano, Hawkins, Wells, Miller, and Brewer (1990) and McWhirter (2008), with perceived choice shown to positively predict young people's treatment progress and treatment attitude.

Previous research has further outlined the impact of non-reflective processes such as affect on PA participation, namely the effect of unpleasant affective experiences during previous physical activity sessions or the effect of positive feelings (P. Ekkekakis, 2017; P Ekkekakis & Dafermos, 2012). Because of this ongoing paradigmatic transition, a stronger focus on integrating young people's perspectives and preferences towards PA has been recommended, including facilitation of preference-based activities, which aims to increase PA enjoyment and autonomous motivation (P. Ekkekakis, 2017).

To summarise, giving young people a voice within the healthcare setting, youth participation, and shared decision-making of youth and clinicians have been shown to lead to improved outcomes, increased participation in treatment and potentially increased autonomous PA motivation, and are key findings of the present research project. Facilitating youth participation, choice and shared decision-making is therefore highly recommended for increasing young people's participation in PA and PA interventions.

5.3.2 Clinical recommendations

Recommendations for clinical practice are made based on the findings of Phase 1 and 2. While it is preferable for clinicians to be trained in all aspects relating to their field, many mental health clinicians will not have received training in their tertiary studies or as professional development in physical activity interventions (Shrestha, Pedisic, Jurakic, Biddle, & Parker, 2021). The recommendations included here are therefore aimed at

clinicians without particular expertise or training and services without extensive funding to include comprehensive physical activity interventions within their service model or capacity to employ physical activity experts, such as exercise physiologists.

1. Integration of PA intervention or PA elements:

   Due to the complexity of young people's presentations, integration of PA interventions with standard psychosocial treatment rather than a replacement of existing treatment options is recommended. Considering physical activity as a potential "supplement" to current treatment introduces the possibility of added benefits for substance use reduction. However, due to the uncertainty of existing evidence, determining its efficacy remains a challenge. Further, consideration should be given to the integration of discrete elements relating to PA, such as scheduling aids, to limit intervention costs and increase acceptability among healthcare service providers, while further research into PA interventions and different dimensions of implementation according to the CFIR is recommended.

2. Assessment of *capability* to participate:

   An assessment of a young person's capability to participate in a PA intervention (or PA) is recommended. Findings of Phase 2 showed that some young people with problematic substance use may present with more complex difficulties than other young people, including severe mental health concerns and physical inactivity. These difficulties significantly impact perceived barriers to PA, which, in turn, lower acceptance of PA interventions overall. Consequently, healthcare service providers are recommended to assess capability and thus identify areas of priority in young people first. Some young people may thus benefit from participating in an integrated PA intervention which aims to reduce their substance use, increase PA participation and consequently improve their mental health. Young people presenting with more complex mental health needs in turn may benefit from simple and achievable PA goals to improve their mental health first and subsequently reduce their perception of barriers to PA and increase their PA participation (for bidirectional relationship of PA and mental health see also Azevedo Da Silva et al., 2012).

   Further, matching interventions to treatment capability has previously shown to increase perceived choice in treatment participation, including a young person's intrinsic motivation to stay engaged in an intervention (McWhirter, 2008), which in turn predicts the outcomes of an intervention (Catalano et al., 1990). Another factor

relating to young people's capability is exercise enjoyment, which has been associated with autonomous motivation and PA maintenance in the past (P Ekkekakis & Dafermos, 2012). Lastly, service-led reduction of barriers limiting young people's capability to participate in PA or PA interventions such as substance use barriers (see Table 16), may increase young people's perceived value of PA participation and interventions and consequently increase PA.

3. Assessment of opportunity and motivation to participate:

   In addition to young people's capability, an assessment of young people's opportunity (e.g., access to various PA opportunities) and motivation is proposed, including negative affect towards PA participation due to previous negative experiences (P. Ekkekakis, 2017). Identification of discrete barriers experienced in these domains may facilitate strategic positioning of service aids to reduce barriers, increase benefits and improve PA behaviour change through positive feedback loops.

4. Matching of treatment stage and intervention format:

   Additional matching of a young person's treatment stage or symptom presentation to intervention format (e.g., supervised, unsupervised, group-based vs individual intervention) is recommended as indicated by young people in Phase 2. For instance, group-based PA interventions were recommended for early treatment stages to increase participation, while individual PA was recommended for later treatment stages to provide increased flexibility and self-efficacy. Overall, reports from young people indicate that appropriate matching of a young person's progress in their treatment (i.e., treatment stage or notable changes in symptoms) with intervention format may hold benefits for participation and motivation.

5. Tailored interventions:

   Tailored interventions according to preferences and individual needs are recommended, as this research (Phase 2) indicated numerous different (perceived) barriers, preferences, and needs in young people with problematic substance use. Tailoring interventions according to these individual differences may increase participation in and acceptance of PA interventions. It may further allow unique combinations of intervention formats, namely a mix of supervised and unsupervised activities, which may limit the burden of intervention delivery on health services and allow young people to develop competencies such as self-efficacy.

Tailoring of interventions was highlighted as part of Phase 1 (Klamert, Bedi, et al., 2023) due to the lack of clarity as to which PA intensities, durations or formats yield superior outcomes for different substance types (Linke & Ussher, 2015; Simonton et al., 2018). Tailoring may overcome these challenges and lead to more successful outcomes through empowering individuals to engage in PA (Thompson et al., 2020).

6. Young-people-centred care:

   Young people's perspectives are an essential part of evidence-based and ethical treatment practice; thus "young-people-centred care", i.e., tailored involvement to the unique needs of a client or client group (Tambuyzer, Pieters, & Van Audenhove, 2014), is recommended. Young people are thus acknowledged as experts in their own experiences and needs, with valuable insights being derived from young people's partnership. Further, young people participating in the qualitative focus group of Phase 2 expressed several psychological benefits of being asked by clinicians to contribute to treatment decisions, such as feelings of being valued and empowered.

5.3.2.1 Clinical recommendations using a real-life clinical example

Based on section 1.8.1 Personal significance: Real-life clinical example, this is used to provide more context and setting to the clinical implications and recommendations from the findings of this research.

1. Assessing capability, opportunity and motivation: Upon admission, a clinician can include an assessment of young people's capability, opportunity and motivation to engage in physical activity. In addition to assessing the current mental state and risk status of a young person, a comprehensive assessment can include sleep, nutrition and identifying the barriers to PA a young person may be experiencing, and a young person's motivation and opportunity to engage in PA. For instance, does the young person have facilities nearby and equipment readily available to engage in PA? In the example provided, several young people expressed a strong motivation to engage in PA; however, they reported significant barriers, inclusing substance use and low physical energy levels, as well as a lack of opportunities to engage in PA due to inconsistent housing. Knowledge of these factors supports the clinician in their treatment decisions and helps them to address these barriers and discuss potential avenues to overcome them.

2. Integrating elements of a PA intervention: As no structured or supervised physical activity intervention was offered as part of the substance use services described in the example, a clinician could integrate elements of a more comprehensive intervention to increase a young person's PA engagement instead. This may include psychoeducation on the effects of PA for substance use reduction, or offering a young person scheduling aids (e.g., to help a young person plan a PA session), engagement aids (e.g., establish a reward system for engaging in PA) or decision aids (e.g., discuss different PA options) to increase PA engagement.
3. Using BCTs: A clinician in the example provided could use behaviour change techniques to increase a young person's PA engagement. For instance, these may include *encouraging a young person to make a behavioural resolution*, *goal setting*, *barrier identification/problem-solving or setting graded PA tasks*. The clinician may further want to *reinforce successful completion* of planned PA tasks. By doing so a clinician can address and increase a young person's PA engagement despite the absence of a structure physical activity intervention, exercise physiologists or other PA trained professions in the service.
4. Tailoring PA intervention: In line with a client-centred approach to care, a clinician could inquire about a young person's preferences and experienced barriers relating to PA to ensure good fit between the suggested physical activities and a young person's needs. If available in a service, a clinician may make a referral to an exercise physiologist to determine a young person's level of fitness (i.e., contributing to capability). A clinician may further ensure that the nature of the intervention is suitable for the young person. For instance, recommending a group intervention to a young person experiencing social anxiety disorder may not be the best option; a young person experiencing low motivation to engage in PA, in turn, may benefit from engaging in supervised rather than unsupervised interventions. In the example provided young people benefited from a supervised, group-based intervention that assisted with managing fluctuating intrinsic motivation and feelings of isolation.

5.3.3 Research recommendations

Several research recommendations are made based on limitations identified in previous research and the current research project (see *5.2.3 Limitations*).

1. Development of a high-quality evidence base:

The development of a rigorous evidence base is required to increase certainty in the evidence and establish a clear effect. This includes additional research into PA interventions for different substance types, investigation of other intervention formats, durations, and PA intensities, and standardisation of intervention reporting and measurement tools to facilitate comparison and synthesis of different studies.

2. Improvement of PA intervention reporting:
   In line with the previous recommendation, there is a need for improved intervention reporting and reporting of implementation characteristics (see also Pascoe et al., 2021). While the former is essential to the reliability and replication of intervention studies, reporting of important implementation characteristics (e.g., implementation barriers, context, implementation strategies) is essential to translating effective interventions into practice and thus increasing the number of effective interventions that are available to affected young people. An example of developing reporting guidelines for PA interventions is provided by Slade, Dionne, Underwood, and Buchbinder (2016), however broad dissemination and extension of the guideline to include implementation characteristics is recommended.

3. Investigation of PA interventions for different substance types:
   With existing evidence on the effect of PA interventions for substance use reduction predominantly focusing on cigarette smoking, additional research on the effect of PA interventions on the reduction of different substance types (e.g., alcohol, cannabis, stimulants) is recommended. Further, an exploration of the efficacy of PA interventions for emerging substance use types is recommended, for instance, the use of e-cigarettes in place of/ in conjunction with regular cigarettes.

4. Comparison of different intervention durations and exercise intensities:
   An in-depth exploration of the efficacy and superiority of different intervention durations, exercise intensities, and intervention types on substance use reduction in young people and different subgroups of young people is recommended. This may enable the strategic allocation of individuals to interventions if a clear effect of PA interventions on substance use has been established.

5. Exploration of essential implementation domains:
   Due to the limited knowledge of several domains which are essential to the successful implementation of physical activity interventions into practice, according

to the CFIR, a thorough investigation of these domains is recommended. While previous research has aimed to explore some of these domains in relation to integrating PA into routine mental health care, a gap in knowledge regarding implementation of pragmatic PA interventions remains (Lederman et al., 2017). This includes, for instance, the outer setting (e.g., policies & laws, local conditions, local attitudes financing) and inner setting domain to substance use treatment services (e.g., relational connections, work infrastructure, physical infrastructure, communications). Increased knowledge of these domains may increase the likelihood of the implementation of a comprehensive intervention, rather than single elements, into substance use treatment services in the future.

6. Investigation of PA for early intervention:

   An in-depth exploration of using PA interventions for early intervention is recommended, which focuses on young people with problematic substance use before their use escalates (Stockings et al., 2016), as well as risk populations. Physical activity may provide an approach for indirectly targeting problematic substance use through physical activity participation, which may also be more acceptable to young people than some other approaches. Further, physical activity does not require young people to perceive their substance use as "problematic"; a common current prerequisite to treatment participation.

7. Development and implementation of a tailored PA intervention (Effectiveness-implementation hybrid approach):

   Last, based on a preceding in-depth investigation of the efficacy of PA interventions, the development, trial and implementation of a tailored PA intervention for young people with problematic substance use into existing substance use treatment practice is recommended. Consideration should be given to effectiveness-implementation designs, which are characterised by a dual focus on effectiveness (i.e. efficacy of a study when trialled outside of a controlled study setting) and implementation (Curran et al., 2012). By applying an effectiveness-implementation hybrid approach, the translation of an effective intervention could be significantly accelerated and be integrated into available treatment options (Bauer, Damschroder, Hagedorn, Smith, & Kilbourne, 2015; Landes, McBain, & Curran, 2019).

1. Co-design with young people:

While co-design is not a new recommendation, it nevertheless emerged as a key finding of the current research project. Qualitative co-design approaches are promoted as highly appropriate for clinical research involving young people (Goodyear-Smith, Jackson, & Greenhalgh, 2015; National Health and Medical Research Council, 2018; VicHealth, 2017, 2019). Further, previous research reported increased empowerment, acceptance, and engagement as a consequence of youth participation in intervention design and development (Dunne et al., 2017). Consequently, it is recommended to invite young people as research partners and integral team members within the process of developing new interventions. Young people may further provide essential insights into current substance usage patterns and consult on acceptability of intervention elements.

5.4 Conclusions

Physical activity may hold benefits for substance use reduction in young people aged 12-25 years and is perceived as highly acceptable and effective by affected young people in Australia. Additionally, young people report numerous benefits of physical activity beyond substance use reduction, including mental health benefits, increased well-being, improved life structure and routine, social connection, increased physical health and empowerment. Consequently, it is suggested that PA or PA interventions are considered for integration into treatment practice for young people with problematic substance use. However, caution should be applied when integrating PA into young people's treatment due to several limitations in the evidence. First, the heterogeneous nature of the existing evidence base impedes synthesising effects to draw robust conclusions regarding the effect of PA interventions on substance use. Second, it remains unclear which intervention types or exercise intensities may be superior to others or if different subgroups of young people require access to different intervention formats. Third, the existing evidence predominantly focuses on the reduction of tobacco use. Thus, no causal inferences can be made for other substance types or changing substance use patterns, such as the rapid increase in e-cigarette use in young people (i.e., vaping).

Additionally, young people with problematic substance use report experiencing several barriers when it comes to participation in PA or PA interventions. These barriers include logistical barriers, access barriers, substance-related barriers, cultural and social barriers and motivational barriers, amongst others. According to the quantitative findings of

this research project, increased barrier perception is associated with decreased PA participation and reduced treatment acceptability of PA interventions. Clinician and service-led identification and reduction of these barriers may lead to an increase in young people's PA participation.

One potential circumvention to current challenges regarding the integration of PA interventions into substance use treatment practice may be the implementation of individual PA-related elements, which purposefully reduce experienced PA barriers and aim to increase the capability, opportunity, and motivation of young people to increase their participation in PA. These elements include, among others, ongoing progress checking, education on potential PA benefits for substance use or providing scheduling aids for PA participation. Strategic implementation of these service elements on the COM-B (capability, opportunity or motivation) dimensions may enhance PA benefits, reduce barriers and increase behaviour change through positive feedback loops. Further, several factors that are essential to the successful implementation of a comprehensive PA intervention (according to the CFIR) have not been investigated yet, e.g., sustainability, cost, relative benefit, burden on healthcare workers, and community acceptance. Implementing individual PA-related elements only may mitigate this challenge and is warranted given the unclear efficacy of PA interventions.

Several recommendations were made based on the findings across the two phases of research reported in this thesis. Recommendations for clinical practice include the assessment of PA "capability" in young people with problematic substance use entering a health service. Such an assessment may help identify young people who may benefit from engaging in integrated PA at the commencement of treatment and young people with more complex mental health concerns who may benefit from focusing on their mental health before considering an integrated PA intervention (a straightforward, achievable PA plan may be considered for this group). Other recommendations included the localisation of barriers impeding young people's capability, opportunity and motivation, strategic placement of service aids; and tailoring interventions to unique, individual needs. Research recommendations include the development of a rigorous evidence-base; improvement and standardisation of intervention reporting; investigation of PA interventions for different substance types; comparison of varying intervention formats, durations and intensities regarding efficacy; and exploration of essential factors contributing to successful implementation and integration of PA interventions into treatment practice.

To conclude, while PA interventions hold promise for substance use reduction in young people, several limitations need to be considered, and more research is needed to draw causal inferences regarding the efficacy of different formats of interventions for reduction of various substance types in young people. Despite the need for further research, the young people included in this research project were clear in their acceptability of PA as part of treatment for substance use and identified many perceived benefits of PA participation for their substance use and overall well-being. The project further showed that there is no "one intervention fits all" solution to integrating PA with the existing substance use treatment practice, rather, clinicians need to identify each young person's barriers and needs and jointly develop a PA intervention plan.

5.5 Chapter Summary

Chapter 5 (Phase 3) integrated findings from Phases 1-2 to discuss the clinical impact of and provide recommendations for research and practice based on the findings of this research project and calls attention to the limitations of the available evidence. While the overall evidence base for the integration of PA interventions into clinical practice for young people with problematic substance use remains underdeveloped, integration of PA or discrete PA elements may have benefits for improving substance use and associated outcomes in young people. However, more research is needed to investigate superior intervention characteristics and establish the efficacy of PA interventions for the reduction of different substance types.

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APPENDIX A

Appendices from Chapter 3, Phase 1, Publication 1 & 3

Physical activity interventions for young people with increased risk of problematic substance use: A systematic review of different intervention modalities

Underreporting of implementation strategies and barriers in physical activity interventions for young people at risk of problematic substance use: A brief report (under review)

Appendix A.1

Registration - International Prospective Register of Systematic Reviews (PROSPERO)

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Appendix A.2

Study characteristics of Publication 1

Supplementary Table 1

Characteristics of acute, short-term interventions

Reference	Country	Setting	Study design	Participants	Experimental condition(s)	Comparison group(s)	Time of assessment	Relevant outcome measures	Study findings	Follow up	ITT
Daniel et al. (2006)	UK	Community	RCT, unimodal	40 (n=23 male, 17 female) sedentary smokers (10 or more cigarettes/day) aged 16- 65 years (mean 23.4), no current psychiatric treatment,	Moderate exercise	Cognitive distraction	Pre/ mid/ post (5min, 10min) intervention	Positive and negative affect: Positive and negative affect scale (PANAS) Smoking withdrawal symptoms (strength of desire to smoke, irritability, depression, tension, restlessness, difficulty concentrating, stress): Mood and Physical Symptoms Scale (MPSS) Desire for cigarette: Single item 'I have a desire for a cigarette right now' Screening: Physical Activity Readiness Questionnaire (PARQ), CO monitoring (Bedfont Smokerlyzer CO monitor), resting heart rate Baseline: Nicotine dependence (Fagerström Test For Nicotine Dependence), 7-day physical activity recall questionnaire, Physical Activity Stages of Change, 2 questions on desire and intention to quit smoking, credibility scale to measure expectations of success of cessation programs	Withdrawal symptoms and desire to smoke (p<.01) significantly lower during exercise group condition (p<.01) compared to control group. Significant lower post-intervention desire for cigarette (p<.001), desire to smoke (p<.001) and withdrawal symptoms (p<.01) intervention compared to control group. Significantly lower post-intervention desire for a cigarette (p< 0.001), strength of desire to smoke (p<0.001) compared to baseline. No significant effect for depression.	No	No
Daniel et al. (2007)	UK	Community	RCT, unimodal	45 (n = 22 male, 23 female) sedentary smokers (10 or more cigarettes/day) aged 16- 65 years (mean 24) no current psychiatric treatment	Positive exercise statement (read)	Ambiguous/ negative statement	Pre (10min, 5 min, 0min)/ mid/ post (5min, 10min) intervention	Smoking withdrawal symptoms: Mood and Physical Symptoms Scale (MPSS) Desire for cigarette: Single item 'I have a desire for a cigarette right now' Screening: Physical Activity Readiness Questionnaire (PARQ), CO monitoring (Bedfont Smokerlyzer CO monitor), resting heart rate, credibility scale to measure expectations of success of cessation programs	Increase in positive expectations of the effect of exercise on withdrawal in intervention group. Significant reduction in withdrawal symptoms (including desire for a cigarette (p<.001), desire to smoke (p<.001)) at post-intervention compared to baseline independently from expectations	No	No

								Baseline: Nicotine dependence (Fagerström test for nicotine dependence), the 7-day physical activity recall questionnaire, Physical Activity Stage of Change measure, 2 questions on desire and intention to quit smoking	(positive/negative/neutral). Significant reduction in depression symptoms at post-intervention (p<.05). Moderate to large effect sizes. No significant between-group differences for withdrawal symptoms (including desire for a cigarette, desire to smoke) during and post-intervention.		
Everson et al. (2006)	UK	Higher education institutions	NRS, unimodal	37 (19 males, 18 females) slightly sedentary (<2x exercise/week) regular smokers (10 or more cigarettes/day) aged 16- 19 years (mean 17.73)	10 min moderate intensity cycle ergometry	Placebo control condition (low intensity cycle ergometry)	Pre/ mid/ post (5min, 30min) intervention	Withdrawal symptoms and strength of desire to smoke: MPSS Exercise-induced affect: Subjective Exercise Experiences Scale (SEES) Screening: Smoking characteristics and resting heart rate, single items (How many cigarettes per day do you usually smoke? At what time did you have your last cigarette? How difficult has it been to stop yourself smoking today? How much of the time have you felt the urge to smoke today? How strong have the urges been? How much have you craved cigarettes today?), single-item scale to assess frequency of physical activity over previous 3 months, nicotine dependence (FTND, Hooked on Nicotine Checklist (HONC)) During exercise: BORG rating of perceived exertion (RPE) scale	No significant differences were detected between the conditions on strength of desire to smoke or withdrawal symptoms during and after each condition.No effect for depression scores was found.	30 min post	No
Everson et al. (2008)	UK	Higher education institutions, community	RCT, unimodal	45 (25 males, 20 females) sedentary, regular smokers (10 or more cigarettes/day) aged 18-25 years (mean 21.8)	10 min moderate/ vigorous intensity cycle ergometry	Passive waiting group	Pre/ mid/ post (5min, 30min) intervention	Withdrawal symptoms and strength of desire to smoke: MPSS Composite MPSS Score Exercise-induced affect: Subjective Exercise Experiences Scale (SEES) Screening: Smoking characteristics and resting heart rate, single items (At what time did you have your last cigarette? How difficult has it been to stop yourself smoking today? How much of the time have you felt the urge to smoke today? How strong have the urges been? How much have you craved cigarettes today?), single-item scale to assess frequency of physical activity over previous 3 months, nicotine dependence (FTND, Hooked on Nicotine Checklist (HONC)) During exercise: BORG rating of perceived exertion (RPE) scale	Significant reduction (p<.01) in desire to smoke during and 5 min after both moderate (d= 0.80 and d= 0.76) and vigorous exercise (d= 1.11 and d= 0.99) compared with the control condition. The moderate (but not the vigorous one) exercise condition had significantly lower overall withdrawal symptoms (composite MPSS score, d= 0.90, p= 0.01) compared with the control condition. No significant effect was found for depression scores.	30 min post	No

Faulkner et al. (2010)	Canada	Community	Within-subject, crossover (acute), unimodal	19 (11 male, 8 female) regular smokers (mean age 24.6)	Brisk walking (10 min)	Passive sitting	Pre/ mid/ post (IP, 10min, 20min) intervention	Screening: nicotine dependence (FTND), 7-day recall International Physical Activity Questionnaire (IPAQ), resting heart rate, CO levels (Bedfont Smokerlyzer) Cravings: Desire to smoke via 7-point Likert scale Objective measures of smoking topography (Clinical Research Support System (CReSS) Pocket): puff count, puff duration, puff volume, interpuff interval (IPI), time to first puff (TTFP) During exercise: BORG rating of perceived exertion (RPE) scale.	Significant longer 'time to first puff'(indication longer abstinence) (p=.05) at post intervention compared to control group (associated with greater reduction in cravings). Lower puff volume and puff count, and shorter puff duration and interpuff interval at 20-minutes postbrisk walking than values at 20-minutes postsitting (subthreshold significance). Posthoc analyses (controlling for abstinence period) for intervention group: significant lower puff volume and shorter puff duration compared to control.	20 min post	No
Ho et al. (2014)	US	Community	RCT, unimodal	8 (male) sedentary, abstinent smokers (mean age 20.1) with no medical contraindications, history of mental illness or recent nicotine consumption	Resistance exercise	No exercise control	Pre/post (IP, 30 min) intervention	Plasma adrenocorticotropin hormone (ACTH): Plasma sample Cortisol: Blood/saliva sample Urge to smoke: Smoking motivation questionnaire (not specified) Withdrawal symptoms: MPSS Participant stress: Participant stress scales (Not specified) During conditions: Serum cotinine concentrations to assess abstinence compliance Baseline: No. of cigarettes smoked in 24h before conditions	No effect was found for resistance exercise on withdrawal symptoms or urge to smoke.	30 min post	No
Janse Van Rensburg and Taylor (2008)	UK	Community	Within-subject, crossover (acute), unimodal	23 (15 male, 8 female) (regular smokers (>10 cigarettes/day) aged 18-50 years (mean 23.1), no past attempt at smoking cessation, no physical contraindications for exercise	Brief exercise condition	Passive control	Pre/ mid/post (IP, 5min, 10min, 15min) intervention	Cigarette cravings: Desire to smoke (Single statement 'I have a desire to smoke' rated on 7-point scale), urges to smoke (10-item Questionnaire on Smoking Urges (QSU) Baseline: Cessation status via CO levels (Bedford smokelyzer), smoking measures (number of cigarettes/day, duration of being a regular smoker), nicotine dependence (FTND) During exercise condition: Borg Rating of Perceived Exertion (RPE), heart rate	Scores significantly lower in intervention condition at all assessments of the QSU Factor 1 (Intention and desire to smoke) and QSU Factor 2 (anticipation of the relief from negative affect by smoking) compared to baseline except at 15 min post treatment (subthreshold decrease). Effect sizes were 1.96, 2.04 and 1.39 at immediately post, 5, 10 min post treatment. Scores significantly lower in intervention condition at all assessments of both factors compared to control except at 15 min post treatment (subthreshold decrease). Effect sizes were 1.47, 1.22	No	No

									and 0.98 at immediately post, and 5 and 10min post. Significantly lower desire to smoke in the intervention condition at all assessments after baseline except at 10 and 15 min post treatment (here decrease, but not significant). Effect sizes were 1.46, 1.2 and 0.93 during, immediately post, and at 5min post treatment.		
Oh and Taylor (2014)	UK	Community	Within-subject, crossover (acute), unimodal	23 (15 males, 8 females) regular smokers (10 cigarettes/day) aged 18-50 years (mean 23.96) who eat 1 chocolate bar/other snacks/day, no physical contraindication to exercise	Brief exercise condition	Passive control	Pre/ mid/ post (IP, 10min) intervention	Attentional bias towards snacking/smoking behaviour: Display of videoclips and measurement of fixation on snacking/smoking/neutral image afterwards Desire to snack: Statements "I have an intense desire to eat a snack/I am craving a snack/I have an urge for snacking" measured on 5-point scale Desire to smoke: Statement "How strong are your smoking urges just now?" measured with 6-point scale (modified from Food Craving Questionnaire-State version- FCQ-S) Affect: Feeling Scale, Felt Arousal Scale (FAS) Baseline: CO levels (Bedford Smokerlyzer) During exercise: Heart rate	Significant reduction in initial attentional bias for smoking after moderate (p<.001) and after vigorous exercise (p<.001) compared with control. Significant reduction from baseline in initial attentional bias for smoking after moderate (p<.91) and vigorous exercise (p<.05). Significant reduction in maintained attentional bias after vigorous exercise (p<.01) compared to control. Significant reduction in maintained attentional bias from base line after vigorous exercise (p<.01). Strength of desire to smoke was significantly lower after both moderate and vigorous exercise midtreatment (p<.001), immediately after treatment (p<.001), 10 min post treatment p<.001) compared to control. Only at 10 mins after treatment there was a significant difference between moderate and vigorous exercise in Strength of desire to smoke (p<.001).	10 min post	No
Prapavessis et al. (2014)	Canada, UK	Community, hospital	RCT, unimodal	30 (female) pregnant smokers (>5 cigarettes/day, >10/day before gravidity) aged 20-40 (mean 25.7) who do not meet national pregnancy exercise guidelines, no current psychiatric treatment, no	Brief exercise condition	Passive control condition	Pre/ mid/ post (IP, 10min, 20min, 30min) intervention	Cigarette cravings: Statement 'How strong is your desire to smoke right now? measured with 7-point scale Tobacco withdrawal symptoms (Irritability, depression, tension, restlessness, difficulty concentrating, stress): MPSS Screening: Physical Activity Readiness, CO levels/ smoking status (Bedford Smokerlyzer),	Cravings were significantly lower following baseline in the exercise compared with the control condition immediately after exercise (p=.044) and 10 min post exercise (p= .018). Only subthreshold significance was found during exercise (p= 0.061) and no significant differences were found	30 min post	No

				physical contraindications to exercise				During exercise condition: heart rate	20 (p= 0.128) and 30 min (p= 0.128) post exercise. No significant differences regarding tobacco withdrawal symptoms were found.		
Taylor et al. (2006); Taylor et al. (2005)	UK	Community	Within-subject, crossover (acute), unimodal	15 (10 male, 5 female) regular smokers (>10 cigarettes/day) aged 18-50 (mean 25.6), no current psychiatric treatment or physical contraindications	Brief exercise condition	Passive waiting condition	Pre/ mid/ post (IP, 10min, 20min) intervention	Urges to smoke: 32-item Questionnaire on Smoking Urges (QSU) (only at baseline and post-treatment) Strength of desire to smoke: Single item assessed via 7-point scale Baseline: CO levels (Bedford Smokerlyzer), average number of cigarettes/day, nicotine dependence (FTND), physical activity (7-day recall of physical activity measure), cigarette craving (statement "I have a desire for a cigarette right now" assessed on 7-point scale) During conditions: heart rate, Borg's Rating of Perceived Exertion (RPE) (only exercise condition) Tension and energy: single items from MPSS, multi-item measures of POMS (37-item version, only at baseline assessed) Affective valence and activation: Feeling Scale (11-point), Felt Arousal Scale FAS (6-point)	Significant time-by-condition interaction (p<.001) in which contrasts revealed a significantly lower desire to smoke at all measurement points after baseline in the exercise condition compared with the control condition. The intervention condition reduced cigarette cravings for up to 20 min after exercise, in comparison with the control condition.	No	No
Wilson et al. (2018)	US	Community, college	Within-subject, crossover (acute), unimodal	46 (35 male, 11 female) regular cannabis users (> 3×/week) aged 18-25 (mean 20.76), no history of substance use treatment/psychiatric treatment, no evidence of current alcohol/drug use disorder, criminal justice involvement or medical contraindications	Craving induction+ moderate intensity exercise (Condition 1) or vigorous intensity exercise (Condition 2)	No exercise condition	Pre/ mid/post (IP, 30min) intervention	Cannabis craving (assessed during exercise): 4 items on urge/desire to use cannabis assessed via Likert scale (first item taken from Marijuana Craving Questionnaire Short Form MCQ-SF) Screening: Phone screening and in-person screening (verification of self-reported substance screening (urine samples, 7 questions on substance use, exercise, eating etc.), Cannabis Use problems Identification test (CUPIT), Drug Abuse Screening Test (DAST-10), Marijuana Use Questionnaire (MUQ), Marijuana Acquisition and Use Patterns Questionnaire (MAUQ), Marijuana Craving Questionnaire (MCQ, short form), Marijuana Problems Index (MPI), Self-Administered Timeline Followback (S-TLFB) Start of each exercise session: past 24-hour licit and illicit substance use, 7-item Physical Activity Readiness Questionnaire (PAR-Q) During exercise sessions: heart rate	Non-significant reductions in immediate post-exercise craving for the moderate and vigorous conditions. No significant differences in the change from pre- to post-exercise craving among the three conditions (p>.10). Exercise intensity did not influence the level of reduction in self-reported craving. Significant increase in the post-exercise craving scores over time for moderate (p<.01) and vigorous exercise condition (p<0.05), but not for the rest condition.	30 min post	No

Note. ACTH= Adrenocorticotropin hormone; ITT= Intention- to- treat analysis; MPSS= Mood and Physical Symptoms Scale; NRS= Non-randomized studies; RCT= Randomized controlled trial

Supplementary Table 2

Characteristics of long-term interventions

Reference	Country	Setting	Study design	Participants	Experimental condition(s)	Comparison group(s)	Time of assessment	Relevant outcome measures	Study findings	Follow up	ITT
An et al. (2013)	US	Online setting	RCT, multimodal	1698 (1230 female, 468 male) participants aged 18 – 30 years (mean: 24) with history of cigarette smoking, regular internet use, live in the United States	Tailored health messages (Condition 1) plus online peer support (Condition 2)	Untailored general interest message	Pre/post (7 weeks, 12 weeks) intervention	30-day abstinence (cigarette smoking): Self-reported Alcohol use: Change in no. of drinking days between baseline/ post-assessment Exercise: Change in exercise days between baseline/ post-assessment (exercise of 20 min or more) Screening and baseline: Self-report (number of days in last 30 days) on cigarette use, alcohol use, exercise	Significant increase in (30-day) smoking abstinence (p<.001) (Significant difference between 2 treatment groups, p=.0058) and likelihood of positive behavior change in drinking/exercise behavior (p<.001) in both intervention groups compared to control. Increase in exercise days and decrease in drinking days (sub-threshold significance).	12 weeks	Yes
Correia et al. (2005)	US	Private university	RCT, unimodal	133 (92 female, 31 male) young adults (mean age 19.8) with recent substance use (previous 28 days)	Activity increase (AI)	No change control or substance use reduction (SR) (Dual active & passive control)	Pre/post (IP) intervention	Number of substance use days: Parallel version of Daily Drinking Questionnaire (DDQ) Alcohol use days: Daily Drinking Questionnaire (DDQ) Standard drinks consumed: Daily Drinking Questionnaire (DDQ) Engagement in exercise behavior: Behavior rating form (BRF)	Significant decrease in post-intervention substance use days (p<.05) and total drinks consumed (p<0.5) in AI group compared to baseline. Significant increase in post-intervention exercise days (p<.001) in AI group compared to controls. Sub-threshold post-intervention decrease in AI group in alcohol use days. Attention: Highly significant decrease in alcohol/substance use days/total standard drinks in SR group.	No	No
Fishbein et al. (2016)	US	Public schools	RCT, unimodal	Three cohorts (N=85, 46 female, 30 male)) of healthy at-risk students >14 years (mean 16.7), attending grade 9-12 of non-traditional high school/ middle school with no contradicting (physical) conditions	Yoga curriculum	No exercise or care as usual	Pre/post (IP) intervention	Multi-rater (student, teacher), multi-method (survey, cognitive, psychophysiological) data: - Dysregulation (emotional, behavioral, cognitive):Abbreviated Dysregulation Questionnaire (ADI)	Subthreshold- significant decrease in frequency of alcohol use for the treatment group (p<.1). Increase in alcohol use in control group. Decrease in marijuana and illicit substance use (subthreshold).	No	No

								- Response to Stress (only involuntary coping subscale): Response to Stress Questionnaire (RSQ) - Negative mood: Brunel Mood Scale - Substance use: Drug Use Screening Inventory-Revised (DUSI-R) - Impulse Control and autonomic stress response (stress task): Stop-Change Task (SCT) - Screening: data on health/fitness level (standard protocol adapted from the YMCA-approved protocol), Physical Activity Readiness Questionnaire (PARQ), heart rate and blood pressure			
Blank et al. (2017); Horn et al. (2013); Horn et al. (2011)	US	High school	Cluster RCT, multimodal	233 individuals (126 female, 107 male) with smoking history aged 14-19 years (mean 16.58), seeking to quit smoking (< 1 cigarette in past 30 days)	N-O-T program plus a physical activity module (N-O-T+FIT)	N-O-T teen cessation program or brief intervention BI (Standard of care) (Dual active & passive control)	Pre/post (3 months after baseline) intervention, follow up (5 months)	Quit rates: Self-classified quit rate (proportion of teens who reporting to be a quitter, regardless of the number of days since the last cigarette), 7-point prevalence quit rate (proportion of teens who reporting no cigarette use in 7 or more days at assessment): Not specified Physical activity levels (20-, 30-, and 60-minutes/day in past 7 days): Physical Activity Survey using items from the 2005 Youth Risk Behavior Survey Baseline: Physical Activity Stage of Change, 2 questions on confidence and importance to quit smoking, credibility scale, baseline smoking history, cessation status (verified via CO levels), BMI No. of cigarettes smoked per day/weekends (baseline and follow-up assessment)	Intervention condition decreased the risk of continued smoking twofold compared to controls. Significantly higher cessation rates in intervention group compared to both controls at 3 months (p<.001, p<.05 and 6 months (p<.001, p<.05) after baseline. Effect sizes were large. Girls quit more successfully. Youths in intervention condition had greater likelihood of cessation (RR: 1.48) at 6 months. Increase in number of days of 20 min of exercise significantly increased likelihood of daily cigarette reduction. Increase in number of days of 30 min of exercise significantly increased likelihood of quitting smoking. Intervention condition: Largest significant increase in exercise for 20/30/60 Min in both males (p<.001, p=.02, p=.003) and females (p=.005, p=.04, p=.02).	3/ 6 months	Yes

Kerr et al. (2013)	US	Community	RCT, unimodal	1654 (990 female, 664 male) African Americans, aged 14-17 years (mean: 15.06), at risk for problematic substance use and poor health	PHAT health education intervention	Focus on Youth (FOY) program	Pre/post (3, 6, 12months) intervention, follow up	Audio computer assisted self-interview: - Dietary behaviour : 12-item index from Youth Risk Behavior System Survey - Physical activity behaviour: 3-item questionnaire from - Youth Risk Behavior System Survey - Substance abuse (alcohol, tobacco, marijuana): via dichotomous measure or lifetime use (Likert scale) - General health knowledge (on alcohol, tobacco, marijuana, cocaine usage, cancers, cardiovascular disease and prevention, dietary and physical activity behaviors): Jemmott et al. 18-item General Health Knowledge Scale	No significant differences in physical activity engagement from baseline to 12 months, but larger post-intervention increase in intervention condition compared to control. Males engaged significantly in vigorous physical activity (p<.0001), moderate physical activity (p<.01), and physical activity to strengthen or tone muscles (p<.0001; Table 5). Males also demonstrated greater rates of increase for moderate physical activity (p<.05). No significant between experimental conditions for all past month substance abuse behavior variables, lifetime alcohol use, and lifetime tobacco use. Increase in all substance use variables rather than decrease.	3/ 6/ 12 months	No
Lane et al. (2012)	US	College, university	Cluster RCT, unimodal	103 (52 female, 51 male) first year students at risk for hazardous drinking (mean age 18)	Exercise group (originally described as the 'control condition')	e-Chug program or self-Management group	Pre/post intervention (IP), follow up (weekly for 5 weeks post intervention)	Alcohol use behaviour (weekly assessments): Total number of drinks each day of the week to calculate estimates blood alcohol content together with height/weight/sex Exercise behaviour (weekly assessments): total number of minutes spent exercising each day of the week Baseline: Open ended questions on drinking behavior, exercise behavior ("On average, how many days per week do you exercise?" "When you exercise, how many minutes do you usually exercise?")	No significant effect of the intervention condition on estimated blood alcohol content (EBAC) was found. Higher pre-test EBAC levels predicted more drinking for participants in the self-management condition (p<.001) and the exercise condition (p=.001), but not in the e-Chug condition (p=.14). Increased weekly exercise minutes for all conditions at post-treatment (but not significant).	weekly for 5 weeks	No
Melamed et al. (2022)	Canada	Hospital/community	Feasibility study, (RCT), multimodal	70 participants (52 received intervention, 24 female, 25 male) aged 16 to 29 (mean age 23.4) with recent psychosis diagnosis	E-platform + health coach	E-platform + educational package	Pre/mid/post (IP) intervention, follow up (24 weeks)	Program engagement (primary measure): Measure of positive attitudes towards health behavior change with single item (Likert scale)	Significant increase in physical activity behavior for intervention group (p<.001). No significant differences over time in health behaviors	24 weeks	No

				(past 5 years), internet access, residing in Canada;				Physical activity (secondary): Simple Physical Activity Questionnaire (SIMPAQ) Tobacco use (secondary): Heaviness of Smoking Index (HIS) Adherence to the Mediterranean Diet (secondary): Mediterranean Diet Adherence Screener (MEDAS) Confidence in making changes in physical activity, nutrition and smoking (secondary): Readiness Ruler (RR) Mood (exploratory): Quick Inventory of Depressive Symptomatology (QIDSSR) Medication adherence (exploratory): Medication Adherence Rating Scale (MARS) Substance use (exploratory): Alcohol, Smoking and Substance Involvement Screening Test (ASSIST) Alcohol use (exploratory): Alcohol Use Disorders Identification Test (AUDIT)	(smoking, alcohol, illicit substance use) or smoking behavior.		
Murphy et al. (1986)	US	University	RCT, unimodal	60 (male) heavy social drinkers (45 drinks/ month or 1.5 drinks/day) aged 21-30 years (mean 24.8)	Exercise/running	No treatment control or meditation group (Dual active & passive control)	Pre/post (IP) follow up (6 weeks follow-up period)	Alcohol consumption behavior (via daily journals and Drinking Habits Questionnaire): Type, amount of alcohol consumed, time spent drinking Other behavioral variables: smoking, other drug use Subject expectancy: 12 open questions (baseline), 12 open questions plus 6 questions on subject's observations/conclusions (follow-up) Maximal oxygen levels to assess aerobic capacity: Monarc-Crescent Model	Significant decrease in alcohol consumption in all groups compared to baseline with largest decrease in intervention group (p<.001). Significantly lower weekly alcohol consumption at weeks 3-6 (p<.0l), weeks 7-10 (p<.05) and 6 week follow up (p<.00l) in intervention group compared to no treatment control. No significant difference in meditation group to other groups.	6 weeks follow-up period	No

Parker et al. (2016)	Australia	Mental health centers	RCT, multimodal	176 (107 female, 69 male) individuals with psychiatric concerns (mild mental disorder or a decline in functioning) aged 15-25 (mean 17.6), no prior formal intervention, psychotic symptoms, suicide plan/intend, organic mental disorder/intellectual disability or exercising according to national guidelines	Physical activity+ problem solving therapy (PST) (Condition 1) or supportive counselling (Condition 2)	Psychoeducation+ problem solving therapy (PST) (Control 1) or supportive counselling (Control 2)	Pre/post intervention (IP)	Depression symptoms: Beck Depression Inventory-II (self-report), Montgomery-Åsberg Depresssion Rating Scale (Observer-rated) Anxiety symptoms: Beck Anxiety Inventory (self-report) Clinical caseness (meeting diagnostic criteria for diagnosis): clinical range on scale scores of BDI-II > 14, MADRS > 7 and BAI > 8 Substance use: Substance and Choices Scale Physical activity frequency and duration: Active Australia Survey (adapted Items 4 and 5 from the International Physical Activity Survey (IPAQ)) Type/ frequency of other interventions received: Unspecified questionnaire During intervention: Monitoring for depression, anxiety, suicidality and psychosis via Brief Psychiatric Rating Scale version 4	Depression symptoms were significantly reduced from baseline (p<.002), the physical activity intervention group improved significantly more than the control (p=.023). There was an increase in physical activity from baseline, but no significant difference between intervention and control groups. No significant effect for alcohol and tobacco was found. There was a significant difference between intervention and control grop for cannabis use (p=.012) with control groups increasing use over time and physical activity groups demonstrating stable use over time.	No	Yes
Prince et al. (2020)	UK	Community	RCT, multimodal	37 (24 male, 13 female) regular cannabis users (>3x/week) aged 18–25 (mean 20.36), no history of treatment for substance use/ psychiatric problem, current use or current criminal justice involvement	CBT+ MET+ Exercise	Learning and using protective behavior skills (PBS)	Pre/ post intervention (IP at 2 months) , follow up (1/3/6 months)	Episodic use of protective behavioral strategies (PBS): Statement “Did you use any of the strategies you learned to help you cut down on smoking weed?” assessed via Ecological momentary assessment (EMA) Episodic cannabis use quantity: measured via EMA Baseline: Past month substance use Sreening: Drug Abuse Screening Test-10	There was a significant reduction from baseline in Cannabis use for the intervention and control group. The intervention group reduced their cannabis use quantity to a significant greater degree than the control group.	1/ 3/ 6 months	No
Rotheram-Borus et al. (2016)	US, South Africa	Community, South African neighborhoods	Cluster RCT, multimodal	142 healthy, unemployed males aged 18-25 (mean 25.7) who reside in respective township >4 nights/week, at risk for poor health and substance use	Soccer program, random rapid diagnostic drug tests	Delayed control condition	Pre/post intervention (at 6 months)	Alcohol and substance use (hazardous alcohol use, symptoms of dependence, harmful use): AUDIT Substance use (different substances, number of use days, the largest dose	The weighted index of combined substance use showed a subthreshold significant reduction in the immediate intervention compared to the delayed control condition (p<.07), serious drug	No	No

					(RDT) and vocational training opportunity			used on a day, withdrawal/use symptoms): Unspecific self-report for last 3/6 months Mental health: Stress (10-item stress measure), depression (Center for Epidemiological Studies of Depression measure (CESD) short form)	use (p<.07), crack use (p<.09). There was a significant reduction in and methamphetamine (p< 0.03) over time compared to the control condition. The control condition was significantly more likely to engage in serious drug use (heroin, cocaine, methamphetamine) (p<.0003). There were no significant differences across conditions for depression.		
Scott and Myers (1988)	Canada	High school, adolescents from Algonquin nation	NRS, unimodal	76 (38 female, 24 male) members of Alonquin nation aged 12-18 (mean 14.6), at risk for problematic substance use and poor health	Culturally appropriate fitness training in first 30 min of every PE class)	PE as usual	Pre/post intervention (IP at 24 weeks)	Fitness: upper body muscular endurance, lower body strength, agility (Canada Fitness Award Program), hamstring flexibility (sit and reach test), cardiovascular fitness (Cooper's 12 Minute Run) Self-evaluations: Physical self-efficacy (Ryckman et al.'s Physical Self-Efficacy Scale), body image (Secord & Jourard's Body Cathexis Scale) Substance use: Native American Drug Use Survey Instrument (40-item)	There was a significant decrease in recent substance use at postreatment (p<.01) and increase (p<.001) in physical activity in the intervention group compared to the control group. Alcohol and drug use remained relatively stable over time in the treatment group but increased somewhat in the comparison group.	No	No
Stanley et al. (2017)	US, United Arab. Emirates	Private schools, expatriate adolescents	Cluster RCT, unimodal	439 (204 male, 234 female) 9th grade students (mean age 13.9) at risk for hazardous smoking behavior, who attend English school with no established health curriculum	Nutrition/physical activity workshop	Tobacco use workshop	Pre/post intervention (2-3 weeks after workshop)	Knowledge, attitudes and beliefs regarding tobacco, nutrition, and physical activity: questions from the World Health Organization (WHO) Global Youth Tobacco Survey (GYTS) and the Centers for Disease Control Youth Risk Behavior Surveillance System	The nutrition and physical activity workshop was not effective in improving knowledge, attitudes and perceptions of nutrition and physical activity; but resulted in a decrease in the teenagers' level of satisfaction with their physical activity.	2-3 weeks	No
Tesler et al. (2018)	Israel	Community, youth advancement center	NRS, multimodal	76 (41 male, 35 female) at-risk youth studying at the youth advancement center (mean age 16.8)	Urban Forest Health Intervention program (UFHIP)	Control condition	Pre/post intervention (IP at 10 months)	Israeli version of the HBSC questionnaire (all variables assessed with this questionnaire): - Physical activity: Questions concerning physical activity in last 7 days	Significant time-by-condition interaction (p<.001) in which contrasts revealed a significantly lower desire to smoke at all measurement points after baseline in the exercise condition compared with the control condition.	No	No

								- Smoking: Statement "How often do you smoke tobacco at present?" (4-point scale) - Alcohol consumption: 2 questions referring to binge drinking and drunkenness - Psychosomatic symptoms: HBSC psychosomatic symptom checklist (8-item) (overall psychosomatic index created)	The intervention condition reduced cigarette cravings for up to 20 min after exercise, in comparison with the control condition.		
Weinstock et al. (2014)	US	College	RCT, multimodal	31 (11 male, 20 female) sedentary (<12× exercise/2 months) and heavy drinkers (>8 score on AUDIT, ≥4 heavy drinking episodes in past 2 months) aged 18-27 (mean 20.55), no current treatment for alcohol-related problems or physical contraindications	Motivational enhancement therapy for PA plus contingency management (MET+CM)	Motivational enhancement therapy (MET)	Pre/post intervention (IP at 2 months)	Alcohol use: number of days, number of heavy drinking episodes, number of drinks per week Physical activity participation (accelerometry) Self-reported exercise: Frequency, weekly duration (minutes), weekly estimated calories expended, estimated V02 peak	Significant increase (large effect) in exercise frequency in all groups (p<.05) with a significant large increase in the intervention condition compared to the control condition. There was no significant effect for drinking outcome variables in the intervention group; the control condition resulted in a (non-significant) numerically greater reduction in heavy drinking episodes than the intervention condition.	No	No
Weinstock et al. (2016)	US	College	RCT, multimodal	70 (31 male, 39 female) sedentary (<2 days/week) students aged 18-25 (mean 20) who meet criteria for hazardous drinking (≥4 heavy drinking episodes in past 2) months, no acute psychiatric problems/ contraindications for exercise/ BMI ≥ 35.0 kg/m2 or desire to receive treatment for alcohol-related problems	Motivational interviewing plus contingency management for exercise (MI+CM)	Motivational interviewing and exercise contracting (MI+EC)	Pre/post intervention (IP at 2 months), follow up (6 months)	Weekly exercise frequency METs hours per week Cardiorespiratory fitness Alcohol use outcomes: binge drinking episodes, frequency, consequences of use	College students in both conditions significantly increased exercise frequency during the intervention period (p<.001) followed by a significant decrease to follow-up (p<.001). Although participants a decrease in exercise frequency between 2- and 6- month follow-up, they were still exercising at greater frequency than baseline. Participants in the intervention condition increased their exercise frequency to a greater extent than those of the control condition (p=.012). Participants significantly decreased the number of binge episodes (p=.007) and consequences associated with alcohol use (p=.001) but there were no	6 months	Yes

									significant differences between treatment conditions.		
Ybarra et al. (2013)	US	Online community	RCT, unimodal	164 (72 female, 92 male) regular smokers (> 4/day or >6 days/week) individuals aged 18-25 (mean 21.6) who want to quit, own a cell phone with unlimited text messaging plan, literate in English	Sleep and physical activity group (originally described as the 'control condition')	SMS USA intervention	Pre/ post intervention (IP at 4 weeks), follow up (3 months)	Smoking cessation: 3 months continuous abstinence assessed via statement "Have you smoked at all, even just a puff, since your quit date?" 7-day point prevalence abstinence (Program acceptability)	Control participants were significantly more likely to have quit at 4 weeks postquit. Findings were not sustained at 3 months postquit. Observed differences in smoking cessation outcomes between groups were not statistically significant.	3 months	Yes

Note. AUDIT= Alcohol Use Disorder Identification Test; BI= Brief intervention; BMI= Body mass index; CBT= Cognitive behavioral therapy; CM= Contingency management; EC= Exercise contracting; IP= Immediately post; ITT= Intention- to- treat analysis; MET= Motivational enhancement therapy; METs= Metabolic equivalent of task; MI= Motivational interviewing; N-O-T= Not On Tobacco program; NRS= Non-randomized studies; PBS= protective behavioral strategies; PE= Physical education; RCT= Randomized controlled trial; RDT= Rapid diagnostic drug tests

Appendix A.3

Intervention characteristics of Publication 1

Supplementary Table 3

Detailed description of characteristics of acute, short-term interventions (TIDieR)

Reference	Experimental description	Comparison description	Personnel delivering treatment	Individual/ group	Mode of delivery	Duration frequency	Maintenance
Daniel et al. (2007)	Positive statement: "Under the positive condition, participants read a prepared statement indicating that exercise is beneficial in terms of withdrawal symptom reduction. [...] Participants were required to exercise for 10 min in their moderate intensity range, between 40 and 60% of their heart rate reserve, using the Karvonen method (Karvonen and Vuorimaa 1988). Each individual completed a warm-up period lasting 1 to 2 min (this was not part of the 10-min experimental period). At 5 min into exercise, they rated their mood via the MPSS (Mood and Physical Symptoms Scale; West and Russell 1985). and then repeated at 10 min. Participants then dismounted the exercise bike and sat down. At 15 min (5 min postexercise), participants completed the MPSS again. They then sat quietly for a further 5 min and completed the MPSS a final time (20 min post-exercise)." (p.127)	Negative statement: "The negative group read a paragraph that stated no effect of exercise on withdrawal had been found by research.[...]" (p. 127) Ambiguous statement: "Under the ambiguous condition, participants read two paragraphs of text, one indicating that there is research evidence pointing to the positive effect of exercise on smoking withdrawal and a paragraph stating that other research had found no effect of exercise on withdrawal symptoms. [...] Participants were required to exercise for 10 min in their moderate intensity range, between 40 and 60% of their heart rate reserve, using the Karvonen method (Karvonen and Vuorimaa 1988). Each individual completed a warm-up period lasting 1 to 2 min (this was not part of the 10-min experimental period). At 5 min into exercise, they rated their mood via the MPSS (Mood and Physical Symptoms Scale; West and Russell 1985). and then repeated at 10 min. Participants then dismounted the exercise bike and sat down. At 15 min (5 min postexercise), participants completed the MPSS again. They then sat quietly for a further 5 min and completed the MPSS a final time (20 min post-exercise)." (p.127)	Not specified, "experimenter"	Individual	In-person; supervised	One single session with one initial screening session a month prior	Not specified
Daniel et al. (2006)	"Participants were required to exercise for 10 minutes in their moderate-intensity range [between 40 and 60% heart rate reserve (HRR)] using the Karnoven method (Karnoven & Vuorimaa 1988). Each individual completed a warm-up period lasting 1–2 minutes. At 4.5 minutes they rated their mood via the MPSS and PANAS but stopped pedalling for approximately 1 minute while completing the questions. Once all questions were completed pedalling resumed, and the MPSS and PANAS were repeated at 10 minutes. Participants then dismounted from the exercise bicycle and sat down. At 15 minutes (5 minutes post-exercise) participants again completed the MPSS and PANAS. They then sat quietly for a further 5 minutes (10 minutes post-exercise) and completed the MPSS and the PANAS for a final time." (p.1189)	"A visual version of the paced audio serial addition task (PASAT; Diehr et al . 1998) was used as the cognitive distracter. Each individual completed a 1-minute practice session prior to starting the task. The PVSAT required participants to monitor the presentation of single-digit numbers presented one per second, reporting aloud the sum of the last two numbers seen. The timing of the administration of the MPSS and PANAS mirrored those in the exercise condition. Participants were asked to do as well as they possibly could, as their performance was being monitored." (p.1189)	Not specified, "experimenter"	Individual	In-person; supervised	One single session with one initial screening session a month prior	Not specified

Everson et al. (2006)	"Participants assigned to the moderate intensity exercise condition exercised on a cycle ergometer for 10 min and were asked to maintain an intensity equivalent to a rating of perceived exertion (RPE) of 11– 13 according to the Borg 6–20 RPE scale (Borg, 1998) after 1 min of familiarisation. HR was also measured during exercise using a Polar BeatR HR monitor. [...] As a measure of exercise intensity, the Borg RPE scale (Borg, 1998) was administered verbally every minute during both conditions, and HR was also measured at this time. The RPE scale was presented on the wall directly in front of the participant as they exercised."(p. 1551)	"Participants assigned to the placebo control condition completed 10 min of very low-intensity exercise in the range of 7–9 on the Borg RPE scale (Borg, 1998) on a stationary cycle, after 1 min of familiarisation. RPE and HR were both monitored each minute throughout both conditions." (p. 1551)	Not specified	Individual	In-person; supervised	One single session	Not specified
Everson et al. (2008)	Moderate intensity condition: "[...] participants assigned to the moderate intensity exercise condition exercised on a cycle ergometer for 10 min at 40–59% heart rate reserve (HRR) and with a goal of keeping within a rating of perceived exertion (RPE) range of 11–13 (Borg, 1998). [...] Heart rate (HR) was measured during exercise using a Polar Beat HR monitor. During both moderate and vigorous intensity exercise RPE and HR were assessed every minute. If participants' HR left the target range, they were instructed to pedal faster or slower accordingly, and/or the resistance was adjusted." (p. 28)1 Vigorous intensity condition:_ "[...] participants assigned to the vigorous intensity exercise condition exercised on a cycle ergometer for 10 min at 60–84% HRR and with the goal of keeping within an RPE range of 14–16." (p. 28)	"Participants assigned to the passive control condition sat quietly for 10 min, without access to distractions." (p. 28)	Not specified, "investigator"	Individual	In-person; supervised	One single session	Not specified
Faulkner et al. (2012)	"walking briskly for 10 minutes on the treadmill at a pace that was similar to if they were 'late for an important appointment'. Heart rate was monitored throughout both testing sessions, while Ratings of Perceived Exertion were obtained every two minutes during the treatments using a flashcard of the Borg scale. Immediately after the testing session (passive sitting or brisk walking), participants were given a 20- minute postcondition ('free-time') interval, during which they were required to have a cigarette, using the CReSS Pocket, at any time that they desired." (pp. 131-132)	"sitting passively for 10 minutes on a chair beside a treadmill" (pp. 131)	Not specified	Individual	In-person; supervised	One single session with screening session within a week prior	Not specified
Ho et al. (2014)	Completion of a 24-hour ad libitum smoking trial, followed by an experimental condition in form of one 24-hour smoking abstinence trial of resistance exercise in the morning and mental challenge tasks in afternoon (EX). "After completing an ad libitum smoking trial (SMO), where all measures were taken at the relevant experimental time points (without exercise or mental challenge), subjects were balanced and randomized into the exercise (EX) or control (CON) trial. These two trials were conducted during a 24-hour smoking abstinence period. [...] After a standardized warm-up protocol, participants per- formed six whole body exercises in a workout designed to maximize hormonal responses (Kraemer et al., 1990). Exercises were completed in the following order: smith squat, bench press, bent-over row, arm curl, Romanian deadlift and sit up. Each exercise consisted of three sets of a 10 repetition maximum (10-RM) with 2.5 min of rest between sets and exercises. {...] Mental challenge sessions were comprised of the mental arithmetic task and the Paced Auditory	Completion of a 24-hour ad libitum smoking trial, followed by an control condition in form of one 24-hour smoking abstinence trials (CON, no exercise in mornings and mental challenge tasks in afternoons). "After completing an ad libitum smoking trial (SMO) [...] Participants replicated dietary intakes for the two days preceding experimental visits. Participants also recorded the number of cigarettes they smoked for 24 h before the SMO, EX, and CON trials. Participants were instructed to refrain from strenuous exercise, alcohol, and any prescription or over-the-counter medication throughout the study. The resistance exercise (EX) and control (CON) conditions were performed in the morning in a fasted state. Mental challenge sessions were performed in the afternoon, at least 2 h after lunch. (p. 696)	Not specified	Individual	In-person; supervised	24-hour smoking trial (SMO) followed by 24-hour control condition or exercise condition	Not specified

	Serial Addition Task (PASAT; Gronwall, 1977). The mental arithmetic task required subjects to continuously add the sum of three digit numbers to the original number as quickly as possible, and to recalculate the answer when a mistake was made (Al'Absi et al., 1997). Subjects performed two five-minute trials, with 1 min of rest between trials. On the PASAT, a pre-recorded tape delivers a random series of 61 numbers (from 1 to 9) every 1.2 s. Participants were asked to sum each number with the preceding number. All partic- ipants performed three trials with 1 min of rest between trials. (p. 696)						
Janse Van Rensburg et al. (2008)	"Exercise condition. Following a brief familiarisation period with the treadmill (to ensure participant's safety), the exercise session commenced with a short warm up (approximately 2 min) followed by a 15-min self-paced walk on a horizontal treadmill and a 1-min cool down. Participants were recommended to walk briskly, as if they were trying to catch a bus or were late for an appointment but not to the point of breathlessness (and were able to request the investi- gator to increase or decrease the pace of the treadmill at any point in the session). This instruction has been previously used to suggest the optimal intensity for a self-paced brisk walk (Taylor et al., 2005). Partici- pants were required to provide the investigator with an oral Rating of Perceived Exertion (RPE) via the 6–20 Borg Scale (Borg, 1998) that was positioned in front of the treadmill every 2 min. A POLAR heart rate monitor, worn throughout the session, allowed exercise intensity to be calculated. Participants were blinded to the heart rate display. Following both sessions, participants were required to remain in the laboratory and respond to measures (cigarette carvings and cognitive functioning) at 5-min time intervals up to 15 min post treatment. At the end of the two sessions, participants were reimbursed £10 for their time." (p. 194)	"Passive control. The control condition involved sitting passively in the laboratory without access to reading materials, mobile phone or internet for 15 min. Passive seating has previously been shown to generate comparatively constant measures in cigarette cravings and self-reported poor concentration (Taylor et al., 2007)." (p. 194)	Not specified, "investigator"	Individual	In-person; supervised	two 15-20 min sessions on 2 consecutive days, 15h abstinence and pre-post assessment	Not specified
Oh et al. (2014)	"The exercise session consisted of a 2 min warm-up, followed by a 15 min cycle ergometer session during which participants were instructed to maintain at either moderate intensity at 40%–50% heart rate reserve (HRR) and 11–13 on a rating of perceived exertion (RPE; using a 6 –20 Borg Scale, Borg, 1998; i.e., fairly light-somewhat hard) or vigorous intensity at 70%–75% HRR and 15–17 on the RPE scale (i.e., hard–very hard; ACSM, 2009), followed by a 2 min cool down. (p. 351)	"Participants sat passively and quietly at a desk for 17 mins." (p. 351)	Not specified	Individual	In-person; supervised	3 different conditions on 3 parallel days, each treatment about 17-20 min	Not specified
Prapavessis et al. (2014)	"The exercise condition entailed a single bout of treadmill walking at a mild-to-moderate intensity (25–55% of heart-rate reserve; Davenport, Mottola, McManus, & Gratton, 2008) for 20 min, which commenced upon reaching the lower limit of the heart-rate prescription. Approxi- mately 2 min and 5 min were allocated for warm-up and cool down, respectively." (p. 704)	"The passive control condition required participants to view a neutral DVD (27 min in duration) about home gardening, in a quiet, isolated room in the laboratory. This control condition has been shown to be acceptable in previous studies (e.g., Ussher, Nunziata, Cropley, & West, 2001)." (p. 704)	Not specified	Individual	In-person; supervised	One single session with screening session 2 days prior (18h abstinence in between)	Not specified
Taylor et al. (2005, 2006)	"Exercise condition After a brief familiarisation with the treadmill lasting approximately 1 min, the exercise session consisted of a 2-min warm-up at 4 km/h, followed by 1-mile of brisk walking on a horizontal treadmill at a preferred intensity, and 2 min cool-down at 4 km/h. It was estimated that the 1-mile walk would take 15–20 min. Participants	"Control condition The control condition involved passive waiting (sitting quietly) without access to reading material, for 40 min, and completion of the same measures as in the exercise condition, at equivalent time points. Previous studies confirmed that passive sitting, as a control condition for	Not specified, "investigator"	Individual	In-person; supervised	two 40 min sessions on 2 days with 15h abstinence and	Not specified

	were instructed to briskly walk as if to catch a bus, but not to the point of breathlessness, and were able to request the investigator to decrease or increase the pace throughout the session as desired. Every 2 min during the walk, participants provided an oral Rating of Perceived Exertion (RPE) using the 6–20 Borg scale (Borg, 1998), with the scale positioned in front of the treadmill in large font. Immediately after the exercise session participants remained seated in the laboratory for 20 min." (p. 3)	examining the acute effects of exercise on urges to smoke, produces relatively stable measures over the duration of a 20-min experiment (Daniel et al. 2004; Ussher et al. 2001)." (p. 3)				pre-post assessment	
Wilson et al. (2018)	"The two exercise conditions involved moderate and vigorous intensity exercise on a cycle ergometer. Exercise intensity was determined using the Karvonen formula (Karvonen, Kentala, & Mustala, 1957) and was consistent with American College of Sports Medicine (ACSM; 2010) guidelines. It was set at resting heart rate (assessed at the first appointment) plus 45-55% (moderate intensity) or 70-80% (vigorous intensity) of each individual's heart rate reserve. [...] Participants completed a 3-minute warm-up on a cycle ergometer [...] immediately prior to starting the 10-minute exercise session. During the warm-up, the resistance (kilopounds or Kp) was gradually increased from a starting point of 0.5, in order to meet and maintain the participant's target heart rate range for the given exercise condition (moderate- or vigorous-intensity). The maximum Kp during the exercise sessions was 1.0 to 1.5 for women and 1.5 to 2.0 for men, and maximum RPM was 100 for both genders. [...] At the end of the 10-minute exercise session, the participant performed a 2-3 minutes cool down and stretching exercises." (p. 8)	"The control condition consisted of 10 minutes of rest, during which the participant sat quietly without access to cell phone, internet, or reading materials. To reduce boredom, participants watched neutral mood (e.g., scenery) images on a computer screen while listening to soft classical music." (p. 8)	Not specified	Individual	In-person; supervised	three different exercise conditions (proceeded by cannabis induction procedure) on three different days, pre-post assessments a, 24h abstinence phase	Not specified

Supplementary Table 4

Detailed description of characteristics of long-term interventions (TIDieR)

Reference	Experimental description	Comparison description	Personnel delivering treatment	Individual/ group	Mode of delivery	Duration frequency	Maintenance
An et al. (2013)	Individually tailored health messages: "The tailored health message group targeted four behaviors as part of a general wellness–framed Web site: cigarette smoking, alcohol use, exercise, and eating breakfast. […] Week 1 focused on building social support for healthy lifestyles. Week 2 focused on eating healthy breakfasts. Week 3 focused on increasing exercise. Week 4 encouraged smoking cessation or reduction in smoking. Week 5 encouraged responsible drinking or abstinence from drinking. Week 6 addressed the "total lifestyle" by asking participants to consider all four of these behaviors. Each weekly session followed the same basic five-step process [...] Participants visit the site and report on their health behaviors. [...] Participants receive motivational messages tailored to	Untailored general interest messages: "The control program (ie, Treatment 1) consisted of six sessions of general interest (ie, not health-related) lifestyle content. Weekly topics included music, finances, relationships, living green, movies, and online dating." (p. 210)	Avatar, online, peer coaches (undergrad students/ recent graduates)	Individual	Online, e-mental health, digital via avatars and text messagin g;	6 weeks online program with assessments at baseline, week 7 and week 12 post-enrolment	Up to 30% of individuals maintained smoking abstinence until week 12.

	individual outcome expectancies for the target behavior. [...] Participants receive goal-setting messages tailored to their individual self-efficacy and social support for the target behavior. [...] Participants receive strategy messages tailored to address perceived barriers to changing the target behavior. [...] Home Page. Summarizes current and past week content. The participant's avatar "makeover host" was integrated through each of these steps. The avatar encouraged behavior change with dialog that was tailored to the individual's experience the previous week. To add variety each week, the avatar was placed within a different magazine-themed environment with an often-humorous connection to the target behavior (eg, a National Geographic–themed "Finding Breakfast in an Urban Jungle", a Yoga magazine–themed "Lung Power"). The avatar also augmented delivery of tailored messages by holding up signs with tailored text and making verbal references and gestures to highlight tailored content in the surrounding page. Additional intervention components in the tailored health message group included a behavior tracking progress bar, a weekly interactive goal-setting activity, and behavior change testimonials from young adults making similar health behavior changes. Participants in the tailored health message group were also asked to set a goal each week for the target behavior. […] individuals were provided free choice about their weekly behavioral goals. Finally, the site incorporated photograph–diary testimonials from other young adults making positive behavior changes." (p. 210) Individually tailored health messages plus online peer support; "Participants who were assigned to the tailored health message plus online peer coaching group received the same message content as those in the tailored health message group. In addition, participants in the peer coaching group selected an online coach from a team of twelve peer coaches. Each week, the peer coach would view each of their assigned participants' behavioral tracking progress charts and health goals and record a personal video message. This message addressed the participant's degree of success with their health goal from the previous week, reviewed trends in the target behavior for the upcoming week, and reinforced the participant's motivation and confidence for their current health goal. Approximately 1–2 days after recording and uploading these personal video messages, the peer coaches would make a brief phone call to each of their assigned participants to assess progress toward meeting their weekly health goal. […]" (p. 210-211)				supervise d		
Correia et al. (2005)	AI Condition: "Participants assigned to the AI condition were instructed to increase the number of days they engaged in both exercise/physical activity and creative/artistic activity, each by 50%. [...] Over the next 4 weeks, members of the SR and AI groups were asked to self-monitor their target behaviors. [...] Members of the AI group were asked to record the number of minutes they spent engaged in exercise or physical activity and the number of minutes they engaged in creative behaviors." (p.22)	No change control, SR Condition: "Participants assigned to the SR condition were instructed to reduce the frequency of their substance use during the next 28 days. […] Both SR and AI participants were given written instructions that included their individualized behavioral targets and were asked to sign a contract indicating they understood the instructions and intended to follow them. Over the next 4 weeks, members of the SR and AI groups were asked to self-monitor their target behaviors. Members of the SR group were asked to record the number of standard drinks consumed each day and to indicate whether or not they had consumed any other substances." (pp.21-22)	Instructions delivered by investigator; intervention/control self-delivered	Individual	Self-delivered, in-person; unsupervised	4 weeks/28 days; daily behavior recording	Not specified
Fishbein et al. (2016)	"Each session followed a structured format that included goals and objectives; weekly mindfulness themes (e.g., focusing in the breath; stress; observing without judgment; awareness of thoughts and emotions; cultivating positive emotion; and skill integration). The sessions followed a consistent sequence that included an opening meditation/centering exercise (5 min); stretching and gentle	"care-as-usual (i.e., students went to their regularly scheduled classes). […] Because of the nature of the school and its use of personalized instruction, there was no PE class that could serve as a control condition." (p. 520)	Lead yoga instructor and assistant instructor of	Group	In-person, student surveys delivered	20 sessions (50 min each), three times/wk over 7 weeks	Not specified

	movements (5 min); yoga postures (30 min) and their sequence; mindfulness prompts integrated into the yoga postures; and a closing meditation (10 min). The session concluded with an affirmation of respect to self and others. [...] Across sessions, yoga postures were gradually added, including postures with increasing rigor. At the same time, the general sequence within sessions remained consistent as students learned new postures. The yoga style was hatha vinyasa flow, which involves sequencing basic yoga postures such that the students move from one posture to the next. The postures moved the body in different ways— bending forward, bending backwards, bending to the side, inverting (i.e., going upside down), twisting, and balancing. The postures were done standing, seated, and laying down. Students were also taught meditation skills, and each session opened and closed with a brief meditation. The intervention was conducted in a dance studio in the school building during students' lunchtime. The studio was private and there were no distractions (e.g., other PE students) in the room. The room did include a mirror but students faced away from it. Students were provided a free lunch after the yoga session to compensate for missing lunch. The study provided yoga mats, props, and eye pillows, which were given to the students at the completion of the intervention. Students were encouraged, but not required, to dress in gym clothes." (p. 521)		similar race/ ethnicity to the students and background in social work.		via laptop; supervised		
Horn et al. (2011, 2013), Blank et al. (2017)	NOT + FIT Condition: "10-15 minute brief advice (Brief advice included scripted advice about the harmful effects of smoking and its long-term consequences; potential withdrawal symptoms upon quitting; and a widely available brochure on how to quit smoking) session at baseline. Youth offered core N-O-T sessions once a week for 10 weeks. Youth received a Challenge Log and a pedometer, which they kept with them throughout the study. The logs incorporated weekly goals, tips, and self monitoring strategies reinforced in the group sessions. Teens recorded daily steps (measured by pedometers) and other daily minutes of activity not measured by steps. A "tear off" record of activity was collected at each session for research purposes. Youth received an additional 5-minute encouragement and instruction by Facilitators, as part of each standard N-O-T session. Generally, this included standardized prompts on fitness and health, tailored for each session: dO It! General instructions. F-I-T challenge: weekly reinforcement" (Horn et al., 2013, p. 127)	Brief Intervention: "10-15 minute brief advice session at baseline" (Horn et al., 2013, p. 127) NOT Condition: "10-15 minute brief advice session at baseline. Youth offered core N-O-T sessions once a week for 10 weeks." (Horn et al., 2013, p. 127)	Trained facilitators (2 per site)	Group	In-person; unsupervised	Nine sessions (50 min/wk); 9 consecutive weeks; assessments at baseline, 3 months and 9 months	Not specified
Kerr et al. (2013)	"PHAT is a culturally tailored intervention for African American adolescents, focusing on 3 dimensions of health behavior (dietary behavior, physical activity, and substance use) for premature cancer and cardiovascular disease prevention. The intervention used various interactive learning activities to increase health knowledge, develop health behavior skills, change attitudes, increase self-efficacy, and explore beliefs regarding personal health behaviors.[...] PHAT utilized cultural pride, goal setting, and instruction in dietary behaviors, physical activity, nutrition cognition, proper sleeping habits, and substance abuse. PHAT is designed to increase healthy behaviors of adolescents through the following: knowledge building, reexamination of beliefs regarding risk and consequences, development of skills to delineate and execute behaviors that reduce health risk, increasing self-efficacy to engage in health-beneficial behavior, and increasing motivation to implement healthy behaviors. PHAT was conducted using group facilitation, role-playing, games, and classroom multimedia messages." (pp. 193-194)	"Focus on Youth (FOY)- a sexual risk reduction HIV/sexually transmitted infection prevention intervention" (p. 193)	Trained facilitators	Group	In-person; supervised	Inconclusive: Possibly 1 year overall duration	"Although the PHAT program was brief, it elicited greater scores for health knowledge for at least one year after implementation. " (p. 198)
Lane et al. (2012)	"The exercise-control condition was similar to the self-management condition, except that peer educators discussed healthy exercise as the target behavior; no mention was made of alcohol use."(p. 125)	e-Chug online program: " This program had two components: participants completed e-Chug online, and then the staff member facilitated a group discussion covering the e-Chug results. The primary differences between the self-management and e-Chug	Self-management condition and	Group	In-person/ partly	One 90 minute session per condition, 5	Training effect was accomplished

		conditions are that self-management focuses on how to change individual behavior and reinforce those changes, while e-Chug provides content tailored to the individual about their current drinking [...]. The e-Chug program thus emphasizes motivating behavioral changes, whereas the self-management program emphasizes how to make behavioral changes. The two programs were similar in that both included information on the effects of alcohol and how to calculate blood alcohol content. Students participated in the programs in groups, with their classmates, and all three programs were approximately 90 minutes in length."(p. 125) Self-management and skill trainings program: "The self-management condition, led by peer educators, focused on teaching the basics of self-management, discussing the effects of alcohol, and determining how to calculate blood alcohol content. As part of the program, participants also identified their own alcohol consumption goal and designed a brief self-management plan to help meet that goal." (pp. 124-125)	exercise control facilitated by trained peer educators; e-Chung condition facilitated by licensed AOD counsellors		online (e-Chung); unsupervised	weeks of assessment immediately after sessions.	for running group. Follow up phase: Subjects in the running condition continued running approx. 2.7 times a week, subjects in the meditation group continued meditation approx. 4.2 times a week.
Melamed et al. (2022)	"The high intensity (HI) group received a TECC intervention. Participants received access to an e-platform, infographic modules and webinars to learn about smoking cessation, physical activity, and nutrition. The research team transferred the NAVIGATE modules into an online format and included supplementary images […]. Participants were assigned a health coach and had weekly one-on-one virtual sessions up to 60 min via the e-platform for 12 weeks to discuss goal setting around health behaviours. The health coaches had Master's degrees in either psychotherapy, public health, psychology, or social work. They had training in Motivational Interviewing and Cognitive Behavioural Therapy and received weekly supervision by a Registered Psychotherapist. During weekly case discussion meetings, for 1 h, the health coach reviewed the participant's goals with a virtual care team (VCT) that included a psychiatrist, addiction medicine specialist, nutrition specialist, recreation therapist and a peer mentor. The clinicians on the VCT remained the same throughout the study, with the consistent role of providing individualized recommendations that were culturally appropriate to the participant's health behaviour change plan and clinical supervision to the health coaches. As the liaison, the health coach communicated the VCT recommendations to the participant, as the participants only had direct contact with their health coach.	"The self-directed learning group (low intensity; LI) received access to the e-platform and educational modules developed by the NAVIGATE programme about smoking, physical activity, and nutrition (i.e., programme designed to provide early and effective treatment to individuals who have experienced a first episode of psychosis) […]. They also received weekly automated e-mails for 12 weeks, reminding participants to review materials and upcoming study appointments. There was no access to the health coach."	E-platform, health coach	Individual	Online (platform, virtual sessions, telephone); unsupervised	12 weeks	Not specified
Murphy et al. (1986)	Exercise/running: "Each subject in the running condition was given a submaximal exercise test under controlled conditions prior to baseline. This test was performed on a bicycle ergometer (Monark-Crescent Model) to assess their aerobic capacity (maximal oxygen consumption level-VOz Max). On the basis of the exercise pretest, subjects in the running condition were assigned an individualized running regimen, tailored to their aerobic capacity. The subjects in the running condition met as a group three times a week, and were asked to run at least some other time per week on their own. Each group session was 70 minutes in duration and consisted of stretching and warm-up exercises before the run, the "run" itself, and stretching and cool-down exercises after the run. Subjects completed the pre- and post-run exercises as a group. Both sessions were 20 minutes in length, and were led by two experienced runners (one a registered nurse). During the post-run exercises, the co-leaders of the group formulated, with each subject individually, a prescribed running level for the next session. The primary exercise	Control condition: Subjects in this condition participated in the pre- and postexperimental laboratory sessions, and kept daily journals of their behavior for the duration of the 16-week study. This condition was included to assess the effects of self- monitoring of daily behavior, repeated administration of the measures in the labora- tory sessions, and any environmental influences on behavior (e.g., academic examina- tion periods that might influence alcohol consumption)." (pp. 178-179) Meditation: "Each subject received individual instruction in the meditative technique developed by Carrington (1978). This technique is clinically standarized, and is a "westernized" version of a mantra-based concentrative meditation technique. Subjects were instructed to regularly repeat a soothing sound (mantra) in their minds for 20	Experienced mediators for meditation sessions, unsupervised for running condition and partly not specified	Group	In-person; unsupervised	Pretreatment period (2 wks), treatment intervention phase (8 wks), follow up period (6 wks); running condition: 3 group sessions/wk + 30 min self-	Not specified

	modes were 30 minutes of a combination of walking and running, or 30 minutes of running. After the 8-week experimental phase, subjects were again tested on the bicycle ergometer to assess VOzMax."(p. 178)	minutes at a time, sitting in a straight-backed chair, in a quiet, dimly lit room. They were further advised to practice this technique once in the morning and once before dinner, seven days a week. Subject instruction was facilitated by the use of workbooks and cassette tapes. Subjects met and meditated as a group three times a week for their "before-dinner- session." Two experienced meditators trained the subjects and were present at the group meditation sessions." (p. 178)				motivated running, meditation group: daily 20 min morning/ dinner sessions, 3 group meditation sessions/week	
Parker et al. (2016)	2 intervention combinations involving behavioral activation and either problem solving therapy or supportive counselling. "Behavioural activation. This intervention was based on behavioural activation principles (e.g., see Veale (2008)) including creating opportunities for the participant to engage in physical activity and monitoring the connection between their mood, anxiety and activity levels. Participants were provided with psychoeducation on the relationship between exercise and mood/ anxiety symptoms, government guidelines for physical activity (Department of Health and Ageing, 2004, 2005), a costs and benefits worksheet about engaging in physical activity, physical activity diaries and pedometers for motivational purposes. The type of physical activity was not prescribed; rather physical activities were tailored and chosen based on the individual participant's interests, prior activities that were enjoyable or offered a sense of achievement, current activity or perceived fitness levels, resources and social supports. The intervention included weekly goal setting, focusing on incremental changes and including incidental activities, and was designed to induce a sense of mastery or achievement in order for participants' to increase positive interactions with their environment and increase opportunities for positive reinforcement (Veale, 2008)." (p. 202)	2 intervention combinations involving psychoeducation and either problem solving therapy or supportive counselling. 'Lifestyle psychoeducation. This intervention provided the same psychoeducation and resources as the behavioural activation intervention, as well as weekly resources focusing on sleep, sub- stance use, and other lifestyle information. This was designed to match weekly session time spent on the intervention in the active group. The resources were discussed in terms of general utility of the content of each, but the therapists did not specifically engage with participants on how to act on the information provided. The importance of physical activity was addressed in the first session but was not included in ongoing intervention." (p. 202)	Research psychologists with master or doctoral level qualifications, assessments conducted by psychology graduate research assistants (trained by principal investigator and supervised by senior investigator)	Individual	In-person; unsupervised	6 face-to-face sessions on weekly basis, post assessment within two weeks after intervention end	Not specified
Prince et al. (2020)	"In the exercise–PA condition, participants were provided with access to three commercially available exercise apps and encouraged to engage in PA as a positive alternative to using cannabis (see Pate, Heath, Dowda, & Trost, 1996; Penedo & Dahn, 2005). During the 8-month study (including the 6-month follow- up), each participant visited the research site on a total of 12 occasions: (a) baseline questionnaires plus app training; (b) four in-person, individualized intervention sessions with an Motivational Interviewing trained counselor; (c) postintervention questionnaires plus app feedback; and (d) follow-ups at 1, 3, and 6 months (total = six visits). [...] The content of each weekly, 60-min session varied within a structured format, which was adapted from Walker et al.'s (2011) MCU- based (Marihuana Check-up) intervention and the Brief Counseling for Marijuana Dependence manual (Steinberg et al., 2005). The content for each of the sessions contained opportunities for individualization, based on each participant's needs. In Session 1, participants completed the Marijuana eCheck-Up (eMCU; Peder sen et al., 2016), reviewing eMCU feedback with their counselor, and developing a change plan. In Session 2, they explored ambivalence about change and learned coping skills. In Session 3, strategies for handling triggers for using cannabis were discussed. Last, in Session 4 strategies for managing moods and plans for using PBSs during follow-up were covered. Participants in	"The content of each weekly, 60-min session varied within a structured format, which was adapted from Walker et al.'s (2011) MCU- based (Marihuana Check-up) intervention and the Brief Counseling for Marijuana Dependence manual (Steinberg et al., 2005). The content for each of the sessions contained opportunities for individualization, based on each participant's needs. In Session 1, participants completed the Marijuana eCheck-Up (eMCU; Pedersen et al., 2016), reviewing eMCU feedback with their counselor, and developing a change plan. In Session 2, they explored ambivalence about change and learned coping skills. In Session 3, strategies for handling triggers for using cannabis were discussed. Last, in Session 4 strategies for managing moods and plans for using PBSs during follow-up were covered." (p. 152)	Counsellor trained in motivational interviewing,	Individual/digital (smartphone app)	In-person/ partly smartphone application; unsupervised	Baseline assessment, four 60-minute intervention sessions, 6 month follow up period	Not specified

	the exercise–PA condition were instructed to continue to use PA as a positive alternative to cannabis use." (p. 152)						
Rotheram-Borus et al. (2016)	"an immediate intervention condition with access to a soccer program, random rapid diagnostic tests (RDT) for alcohol and drug use, and an opportunity to enter a vocational training program (n = 72) [...] Access to job training was provided to the 35 young men with the most on-time arrivals at practice, drug-free RDT, and no red cards for violence." (p. 1841) "During the pre and post- game periods, coaches discussed the four topics above in the following sequence: 1. Start with asking the young man to notice the positive events or success in his life today; 2. Ask the young man about any current concerns; help the man problem solve the situation; 3. Discuss today's health goal, roleplay difficult situations needing these skills, and the way to meet the goal." (p. 1843) "In interactions, the coach discussed and created role-plays around: 1. The consequences of alcohol and drug use and the long term physical, social, family, and community effects of abuse; young men abusing drugs and alcohol were referred to health clinics. 2. Interacting effectively with health care providers, partners, and family members about one's health, especially HIV, HIV testing, diabetes, TB, and drug abuse. 3. Creating enjoyable daily routines and a healthy social network, especially with the women in their life in a respectful and caring manner. 4. Working out and the benefits of exercise. 5. Young men's relationships with women and men's use of violence." (p. 1843) "Any man reaching 55 points was offered vocational training 4 months filling 35 slots. Men were invited to attend an eight-week course in either electrical or mechanical engineering at a local college. In training, the men were provided with safety jackets and boots as well as books, pens, and other necessary materials. For those earning access to the training, the program was conducted twice a week from 9 a.m. to 1:30 p.m. within walking distance of the neighborhoods; young men could still attend soccer after their vocational training classes. The training was practical, with men practicing the skills they had acquired (e.g., safety, using hand tools, servicing a vehicle, wheel alignments, and typology of cars) on electrical and mechanical engineering projects. The courses were introductory; after successful completion, the participants would be able to apply for an entry level job in or begin a small informal business." (p. 1844)	Delayed control condition: same as intervention condition	Soccer coaches	Group	In-person; unsupervised	6 month intervention delivery	Not specified
Scott et al. (1988)	"Treatment was administered during the first 30 minutes of normally scheduled gym classes (conducted every other day on a 4 day cycle for 70 minutes). Physical fitness training designed to enhance aerobic capacity, flexibility and strength, was conducted by the principal researcher, a certified fitness instructor and a member of the River Desert Community. While the regular physical education classes received by ed by the comparison groups) emphasized sports- specific skills, overall conditioning was the focus of fitness training. With the instructor's assistance, students were also encouraged to set personal fitness-related goals [...] Interim fitness testing was conducted at the end of each month to assess goal achievement and fitness progress." (p. 425)	"While the regular physical education classes received by ed by the comparison groups) emphasized sports- specific skills […]" (p. 425)	Principal researcher (fitness instructor and member of River Desert Community)	Group	In-person; supervised	24 week intervention phase, pre and post assessments immediately before and after	Not specified

Stanley et al. (2017)	Nutrition/physical activity workshop: "After administration of the pre- workshop survey, a peer-mediated tobacco or nutrition and physical activity workshop was conducted. [...] An analogous nutrition and physical activity workshop was also implemented [...]. The focus of each workshop was to provide accurate and useful information that students could use to make healthy decisions and to complete exercises that improved attitudes towards healthy lifestyles. The workshop materials consisted of a brief workbook and several props to make the workshop more interactive. Power- Point presentation was not used. Two of the authors (LWA and ZDS), both university students who were trained and had experience as health educators and curriculum designers, designed and taught the workshops. Each workshop lasted the duration of 1 class period, generally 45 minutes." (p. 482)	Tobacco use workshop: "After administration of the pre- workshop survey, a peer-mediated tobacco or nutrition and physical activity workshop was conducted. The tobacco workshop was organized into subsections that focus on the following: the importance of talking about tobacco as a teenager, what tobacco is, long and short term effects of tobacco smoking on the human body, different types of tobacco smoking that are common in the region, influences on teen smoking, and the benefits of tobacco cessation. [...] The focus of each workshop was to provide accurate and useful information that students could use to make healthy decisions and to complete exercises that improved attitudes towards healthy lifestyles. The workshop materials consisted of a brief workbook and several props to make the workshop more interactive. Power- Point presentation was not used. Two of the authors (LWA and ZDS), both university students who were trained and had experience as health educators and curriculum designers, designed and taught the workshops. Each workshop lasted the duration of 1 class period, generally 45 minutes." (p. 482)	Peers (trained university students with experience as health educators/ curriculum designers)	Group	In-person; supervised	1 class period (45 Min) with assessment prior and 2-3 weeks after	Not specified
Tesler et al. (2018)	"The intervention program took place three times a week, with activities focusing on physical activity, such as developing physical fitness, bike riding, rope climbing, and hiking. Sessions on nutrition and physical activity were led by experts: a dietician, a psychologist, two physical education teachers, and five counselors. There were additional activities relating to group dynamics and developing personal and group leadership. [...] Each activity lasted about 60 min, and was led by an instructor who guided the students in the activity at the urban forest and then brought them back to the youth advancement center. After choosing activities for the first session, students were not allowed to switch during the program. Two additional sessions were held for all participants and their families—a joint activity that included nature outings and workshops. During the program, discussions were held with the participants regarding the activity performed and their satisfaction with the program. At the end of the program, a group meeting was held with the entire team of instructors, adolescents, and their families.." (p. 3)	N/a	Dietician, psychologist, two physical education teachers, five counselors	Group	In-person; supervised	60-Min activities 3 times/wk for about 10 months	Not specified
Weinstock et al. (2014)	MET +CM Condition: “Participants randomly assigned to this condition received the same MET intervention as outlined above, plus 8 weeks of CM for exercise. […] interventionist and participant met briefly each week to review the previous week’s exercise activity contract, award any reinforcement earned for completion and verification of exercise activities, and collaboratively develop a new exercise activity contract for the upcoming week. The exercise activity contracts identified three specific exercise activities to be completed by the participant within the upcoming week. Options included walking with a pedometer, walking or jogging on a treadmill for 15 minutes, or attending an exercise class at the gym. Each exercise bout was explicitly defined in terms of duration and length, as well as objective verification needed for proving completion. […] Brief video clips (via a cellular phone or digital camera) of resistance exercises or an aerobics instructor’s note confirming an individual’s attendance also served as verification of exercise bout completion. […] Towards the end of the intervention period, the exercise activities contracts could contain more than one bout of exercise per “activity” as some individuals were exercising five days per week and there were spots for only three activities per contract. Participants earned a draw from a prize bowl for each verified exercise activity completed. If all three activities were completed and verified within one week, s/he got bonus draws that started at three draws and escalated over time with successful completion of the all three exercise activities. […]	MET Condition: "The MET session lasted approximately 50 minutes and was framed as a “wellness intervention” for increasing exercise. Interventionists provided personalized feedback about the student’s exercise habits in comparison to population norms (Keating et al., 2005) and exercise guidelines at the time (ACSM, 2007). Next, a discussion about how exercise fit within the participant’s lifestyle goals and values was conducted. Last, the student in conjunction with the interventionist developed a change plan to begin exercising. Drinking was not discussed as part of the MET intervention, unless the participant brought up alcohol use as an impediment to exercising." (p. 8)	Kinesiologist, clinical psychologist	Individual	In-person; unsupervised	baseline/ post assessment (including 4 days of accelerometry monitoring each), either one 50 min MET session vs. one 50 min MET session plus 8 weeks CM for exercise	"Although exercise appeared to increase across participants as a whole, there were no significant changes or differences in drinking behavior over time or by treatment

	The prize bowl for drawings contained 80 slips of paper, and all slips were returned to the prize bowl after participant drawings to maintain probabilities. Half of the slips stated “Good job!”, but were not associated with a prize. The other half were winning slips: 34 stated “small prize”, five stated “large prize”, and one stated “jumbo prize” (p. 7-8)						condition over time." (p. 11)
Weinstock et al. (2016)	MI+ CM condition: “The interventions were alike in that participants received two 50-minute MI sessions, plus 8 weekly individually-delivered exercise contracting sessions. The difference between the conditions was that the MI+EC intervention reinforced participants for attending the exercise contracting sessions (regardless of exercise activity completion) while the MI+CM intervention reinforced participants only for completion of verified exercise activities. Specific components of the interventions are described below • MI and weekly contingency management for exercise (MI+CM) (Condition 2): The first MI session was provided immediately after completion of the baseline assessment to ensure delivery of at least part of the intervention. The second MI session was scheduled 4 weeks later. The MI sessions were framed as a “wellness intervention” for increasing exercise [...]. [...] Participants in the MI+CM were reinforced for completion and verification of exercise activities specified on the weekly exercise contract. Participants earned one draw from a prize bowl for each exercise activity completed. For each week in which at least three activities were completed, participants received bonus draws, and bonus draws started at 3 and escalated over time by 1 draw per week to a maximum of 10 bonus draws per week. […] The prize bowl for drawings contained 80 slips of paper. Half (40) of them stated “Good job!” and were not associated with a prize. The other half were winning slips: 34 state “small prize”, 5 state “large prize”, and 1 states “jumbo prize”. (pp. 7-8)	MI+EC Condition: "The first MI session was provided immediately after completion of the baseline assessment to ensure delivery of at least part of the intervention. The second MI session was scheduled 4 weeks later. The MI sessions were framed as a “wellness intervention” for increasing exercise [...]. [...] The exercise contracting sessions were held over 8 consecutive weeks […]. These sessions were approximately 10–15 minutes in length. Collaboratively, the therapist and participant completed an exercise contract. The contract contained at least three specific exercise activities to be completed within the upcoming week. Exercise activities were selected by the participants to ensure the activities were of interest. Activities ranged widely and included jogging on a treadmill, attending an exercise class, and swimming. Each activity was explicitly defined in terms of intensity and duration (minutes), as well as objective verification needed for proving completion. Objective verification included pedometers, cellphone videos of instructors verifying attendance at an exercise class, and digital pictures for team sports participation. In the subsequent weeks, the therapist met briefly with participants to review the prior week’s exercise contract and verification, problem-solve any issues with exercising, and create a new exercise contract for the upcoming week. As participants were sedentary at the baseline evaluation, the goal of the intervention via the exercise contracting was to increase over time […]."(p. 7)	Therapists (interventions), assessments (research assistants)	Individual	In-person; unsupervised	Two 50-minute MI sessions, plus 8 weekly EC sessions with pr-post assessment and 4 month follow-up (6 months after baseline)	"Although participants as a whole showed a decrease in exercise frequency between 2- and 6- month follow-up, they were still exercising at greater frequency than baseline." (p. 10)
Ybarra et al. (2013)	Sleep and physical activity group: "participants received a text-messaging program that was similar to the intervention program on the number of text messages received per day across the 6 weeks. For example, both intervention and control participants received nine messages on their Quit Day and the day after, but control group messages did not mention that it was the participant’s quit day. Message content was aimed at improving one’s sleep and exercise habits within the context of how it would help the participant quit smoking. Messages were not tailored based on quitting stage (e.g., Pre-Quit vs. Early Quit) nor were Text Buddy and Text Crave components available to this group" (p. 1387)	SMS USA intervention (Control and intervention messages started 2 weeks prior to quit date): "Intervention group participants were exposed to a 6-week cessation program. Content was tailored based upon where in the quitting process participants were: All participants received 2 weeks of Pre-Quit messages aimed at encouraging them to clarify reasons for quitting and to understand their smoking patterns and tempting situations/triggers/urges. Early Quit messages, sent on Quit Day and through the first week postquit, talked about common difficulties and discomforts associated with quitting and emphasized the use of coping strategies. Late Quit messages encouraged participants to recognize relapse in a different way (e.g., situations, confidence) and provided actionable information about how to deal with issues that arise as a nonsmoker (e.g., stress, moods). […] intervention participants received a text message at Post-Quit Day 2 and 7 that asked their smoking status. At either time point, if participants reported smoking, they were pathed to Relapse messages that focused on helping them get back on track and to recommit to quitting. If participants were smoking at both days, they were pathed to an Encouragement arm that focused on norms for quitting and suggested that participants try quitting again at later time. Participants received four messages per day during the 2-week Pre-Quit stage, with the exception of Day 1 and Day 14 when they received five and six messages,	Not specified, computerized text messages and text messages sent by anonymous program buddies	Individual	Text messages, online; unsupervised	6 week SMS intervention program, assessment at baseline, 4 weeks postquit and 3 months postquit	Maintenance significant for intervention group until 4 weeks postquit date, however not significant at 3-month postquit.

respectively. In the Early Quit stage, participants received nine messages on both Quit Day and Post-Quit Day 2, eight messages on the third day, and then one fewer message each day until the last day of the week when four messages were received. In Late Quit, participants received two messages per day for 2 weeks and then one message per day during the final week. Participants in Relapse received two messages per day; those in Encouragement received one message per day for 4 days. Intervention group participants had access to two program components first used in the STOMP NZ program (Rodgers et al., 2005): (a) Text Buddy (another person in the program that a participant was assigned to so they could text one another for support anonymously during the program; assignment was sequential so that buddies would be in similar stages during the quitting process); (b) Text Crave (immediate, on-demand messages aimed at helping the participant through a craving). A project Web site (StopMySmoking.com) provided additional quitting resources, technical support, and a discussion forum." (p. 1389)

Appendix A.4

Risk of bias assessment

Supplementary Table 5

Risk of bias assessment for all included RCTs (Cochrane RoB2)

Study	Sequence generation	Allocation concealment, randomization failures	Blinding, non-protocol interventions/analyses	Outcome assessment	Missing outcome data	Select. outcome reporting	Other sources of bias
(An et al. 2013)	L	SC	SC	L	L	SC	SC
(Correia et al. 2005	SC	SC	SC	L	L	SC	L
(Daniel et al. 2006)	SC	SC	SC	L	SC	SC	SC
(Daniel et al. 2007)	L	SC	SC	SC	L	SC	L
(Everson et al. 2008)	SC	SC	SC	L	L	SC	SC
(Faulkner et al. ,2012)	L	SC	H	L	L	L	H
(Fishbein et al., 2016)	SC	SC	H	L	H	SC	SC
(Ho et al., 2014)	L	SC	SC	L	SC	H	SC
(Horn et al., 2011, 2013, Blank et al., 2017)	L	SC	SC	L	SC	L	L
(Janse Van Rensburg et al., 2008)	SC	SC	H	L	L	SC	L
(Kerr et al., 2013)	L	L	SC	L	L	SC	L
(Lane et al., 2012)	SC	SC	SC	H	H	H	SC
(Melamed et al., 2022)	SC	SC	SC	L	L	SC	L
(Murphy et al., 1986)	SC	SC	H	H	H	H	SC
(Oh et al., 2014)	SC	SC	H	L	H	L	L
(Parker et al., 2011)	L	L	SC	L	L	SC	L
(Prapavessis et al., 2014)	L	L	L	L	H	SC	H
(Prince et al., 2020)	L	L	SC	H	SC	H	SC
(Rotheram-Borus et al., 2016)	SC	SC	H	L	L	SC	H
(Stanley et al., 2017)	SC	SC	SC	H	L	SC	H
(Taylor et al., 2005, 2006)	L	SC	SC	L	L	SC	L
(Weinstock et al., 2014)	H	SC	SC	L	L	SC	SC
(Weinstock et al., 2016)	L	L	SC	L	L	SC	L
(Wilson et al., 2018)	SC	SC	H	L	L	L	SC
(Ybarra et al., 2013)	L	SC	L	SC	SC	L	SC

Note. Sequence generation: SC = Sequence generation/randomisation process not specified (Correia et al., 2005; Daniel et al., 2006; Everson et al., 2008; Fishbein et al., 2016; Janse Van Rensburg & Taylor, 2008; Lane et al., 2012; Murphy et al., 1986; Oh & Taylor, 2014; Rotheram-Borus et al., 2016; Stanley et al., 2017; Wilson et al., 2018), manual allocation (Melamed et al., 2022); H = Baseline differences reported (Weinstock et al., 2014). Allocation concealment, randomization failures: SC = Not sufficiently specified (An

et al., 2013; Correia et al., 2005; Daniel et al., 2006, 2007; Everson et al., 2008; Faulkner et al., 2010; Fishbein et al., 2016; Ho et al., 2014; Janse Van Rensburg & Taylor, 2008; Lane et al., 2012; Melamed et al., 2022; Murphy et al., 1986; Oh & Taylor, 2014; Rotheram-Borus et al., 2016; Stanley et al., 2017; Taylor et al., 2005; Wilson et al., 2018), randomization issues reported (Ybarra et al., 2013); H = Randomisation failures and baseline differences reported (Horn et al., 2011; Weinstock et al., 2014). Blinding, non-protocol interventions/analyses: SC = Blinding unclear, no protocol for comparisons (An et al., 2013; Correia et al., 2005; Daniel et al., 2006, 2007; Everson et al., 2008; Ho et al., 2014; Horn et al., 2011; Kerr et al., 2013; Lane et al., 2012; Prince et al., 2020; Stanley et al., 2017; Taylor et al., 2005), SC = Blinding unclear, but no deviations from protocol visible (Weinstock et al., 2014; Weinstock et al., 2016), SC = Not blinded, but assessors blind to allocation (Parker et al., 2016); H = Blinding unlikely or no blinding, no protocol for comparisons (Faulkner et al., 2010; Janse Van Rensburg & Taylor, 2008; Oh & Taylor, 2014; Wilson et al., 2018), no blinding, but no deviations from protocol visible (Fishbein et al., 2016; Melamed et al., 2022; Rotheram-Borus et al., 2016), not blinded and drop-outs due to group assignment (Murphy et al., 1986). Outcome assessment: SC = Data analysis methods not stated, not stated how HR was measured (Daniel et al., 2007), some participants not randomised and included in analysis (Ybarra et al., 2013); H = Assessment likely not standardized or validated (Lane et al., 2012; Murphy et al., 1986; Prince et al., 2020), reliability or validity of outcome assessment unclear in given cultural context (Stanley et al., 2017). Missing outcome data: SC = Unclear drop-out rate, not ITT (Daniel et al., 2006; Ho et al., 2014), high levels of missing data, but ITT performed (Horn et al., 2013; Horn et al., 2011), medium drop-out rate, no ITT (Prince et al., 2020), some participants not included in ITT analyses (Ybarra et al., 2013); H = High drop-out rate, no ITT (Fishbein et al., 2016; Lane et al., 2012; Murphy et al., 1986), faulty reported drop-out rate, no ITT (Oh, 2011). Selective outcome reporting: SC = Not all outcome data adequately reported (An et al., 2013; Fishbein et al., 2016; Janse Van Rensburg & Taylor, 2008; Melamed et al., 2022; Parker et al., 2016; Prapavessis et al., 2014; Taylor et al., 2005; Weinstock et al., 2014; Weinstock et al., 2016), adequate assessment is judged impossible (Correia et al., 2005; Daniel et al., 2006, 2007; Everson et al., 2008; Kerr et al., 2013; Rotheram-Borus et al., 2016; Stanley et al., 2017); H = Selective outcome reporting (Ho et al., 2014; Lane et al., 2012; Prince et al., 2020), no assessment possible and use of non-validated measurement tools (Murphy et al., 1986). Other resources of bias: SC = Unclear if adjustments were made for multiple comparisons (Murphy et al., 1986), bias reported in publication but not addressed how they were managed (Weinstock et al., 2014), blocked randomisation in possibly unblinded study (Everson et al., 2008; Lane et al., 2012), small sample size, that was not powered to detect differences between the two groups (Ybarra et al., 2013), unclear management of study limitations (Wilson et al., 2018), unclear if adjustments performed and no descriptions of limitations (Fishbein et al., 2016; Ho et al., 2014), prospective randomised trial (Daniel et al., 2006; Prince et al., 2020). H = Improper management of study limitations (Prapavessis et al., 2014; Rotheram-Borus et al., 2016; Stanley et al., 2017), within-subject crossover design, unadjusted estimates (Faulkner et al., 2010), prospective randomised trial, clustering possibly not accounted for .

Supplementary Table 6

Risk of bias assessment for included NRS (non-RCTs) (Cochrane ROBINS-I)

Study	Confounding	Allocation	Intervention classification	Deviations from intended interventions	Missing outcome data	Outcome assessment	Outcome reporting	Other sources of bias
(Everson et al., 2006)	L	M	L	NI	L	C	NI	L
(Scott et al., 1988)	S	M	L	NI	S	NI	S	NI
(Tesler et al., 2018)	NI	S	L	NI	L	S	L	C

Note. Confounding: S = Clusters not comparable, potential confounding. Allocation: M = Allocation according to order in which participants presented (Everson et al., 2006); M = Allocation according to predefined characteristics ; M = Unclear allocation (Scott & Myers, 1988); S = Students self-selected into study/intervention group (Tesler et al., 2018). Missing outcome data: S = High drop-out rate (Scott & Myers, 1988). Outcome assessment: C = Exercise intensity not measured (Everson et al., 2006); S = Subject to social desirability bias (Tesler et al., 2018). Outcome reporting: S = Only significant measures reported (Scott & Myers, 1988). Other sources of bias: S = Significant baseline differences and crossover effects, prospective study, no clear adjustments ; C = Big difference in N between intervention/control group, potential conflict of interest (Tesler et al., 2018).

Appendix A.5

Excluded studies

Primary search 2021:

Reference	Title	Reason for exclusion
Abrantes et al. (2017)	Developing a Fitbit-supported lifestyle physical activity intervention for depressed alcohol dependent women	Adult population
Abrams et al. (2008)	Getting young adults to quit smoking: A formative evaluation of the x-pack program	Wrong intervention
Afifi Soweid et al. (2003)	Changes in health-related attitude and self-reported behaviour of undergraduate students at the American university of Beirut following a health awareness course	Wrong patient population
Agus et al. (2019)	Cost-effectiveness of a combined classroom curriculum and parental intervention: Economic evaluation of data from the steps towards alcohol misuse prevention programme cluster randomised controlled trial	Wrong intervention
Alessi et al. (2020)	Reinforcing exercise to improve drug abuse treatment outcomes: A randomized controlled study in a substance use disorder outpatient treatment setting	Wrong patient population
Allara et al. (2019)	Effects of a prevention program on multiple health-compromising behaviours in adolescence: A cluster randomized controlled trial	Wrong patient population
Allara et al. (2015)	A prevention program for multiple health-compromising behaviors in adolescence: Baseline results from a cluster randomized controlled trial	Wrong intervention
Allen et al. (2018)	High-intensity interval training and continuous aerobic exercise interventions to promote self-initiated quit attempts in young adults who smoke: Feasibility, acceptability, and lessons learned from a randomized pilot trial	Wrong patient population
Anderson et al. (1997)	Cardiovascular risk factor screening and intervention in African American adults	Adult population
Anthony et al. (2015)	Reducing health risk factors in workplaces of low and middle-income countries	Wrong patient population
Ashtobn et al. (2017)	Feasibility and preliminary efficacy of the 'Heyman' healthy lifestyle program for young men: a pilot randomised controlled trial	Wrong intervention
Aveyard et al. (2007)	Does exercise in adolescence prevent smoking uptake?	Wrong format
Babiss et al. (2009)	Sports participation as a protective factor against depression and suicidal ideation in adolescents as mediated by self-esteem and social support	Wrong study design
Bagnardi et al. (2011)	'Alcohol, less is better' project: Outcomes of an Italian community-based prevention programme on reducing per-capita alcohol consumption	Wrong patient population
Bayne-Smith et al. (2004)	Improvements in heart health behaviors and reduction in coronary artery disease risk factors in urban teenaged girls through a school-based intervention: The path program	Wrong outcomes

Bhiri et al. (2015)	A 3-year workplace-based intervention program to control noncommunicable disease risk factors in Sousse, Tunisia	Wrong patient population
Blom et al. (2020)	Impact and implementation of healthy life centres, a primary-care service intervention for behaviour change in Norway: study design	Wrong study design
Blowers et al. (2007)	Impact of an after-school martial arts program on at-risk students	Wrong format
Bock et al. (1999)	Exercise effects on withdrawal and mood among women attempting smoking cessation	Adult population
Bond et al. (2004)	The gatehouse project: can a multilevel school intervention affect emotional wellbeing and health risk behaviours?	Wrong intervention
Bonevski et al. (2012)	Addressing smoking and other health risk behaviours using a novel telephone-delivered intervention for homeless people: a proof-of-concept study	Wrong comparator
Bowen et al. (2018)	Changing the housing environment to reduce obesity in public housing residents: a cluster randomized trial	Adult population
Brick et al. (2016)	Understanding stage of change transitions across multiple behaviors	Wrong format
Brown et al. (2009)	Aerobic exercise for alcohol recovery: rationale, program description, and preliminary findings	Adult population
Brown et al. (2002)	Outcome evaluation of a high school smoking reduction intervention based on extracurricular activities	Wrong intervention
Butcher et al. (1988)	Heart smart: A school health program meeting the 1990 objectives for the nation	Wrong format
Butzer et al. (2017)	Evaluation of yoga for preventing adolescent substance use risk factors in a middle school setting: A preliminary group-randomized controlled trial	Wrong population
Camerion et al. (2015)	A theory-based online health behaviour intervention for new university students (u@uni:lifeguide): Results from a repeat randomized controlled trial	Wrong study design
Campbell et al. (2002)	Effects of a tailored health promotion program for female blue-collar workers: Health works for women	Adult population
Campbell et al. (2008)	An informal school-based peer-led intervention for smoking prevention in adolescence (ASSIST): A cluster randomised trial	Wrong intervention
Chandler et al. (2015)	Resilience intervention for young adults with adverse childhood experiences	Wrong intervention
Chaney et al. (2008)	Weight gain among women during smoking cessation: Testing the effects of a multifaceted program	Adult population
Ciccolo et al. (2016)	Acute effects of resistance exercise on affect, arousal, and urge to drink in temporarily abstinent young adult hazardous drinkers	Adult population
Cole et al. (2001)	From Joe Camel to hip, fit girls!	Wrong intervention
Collingwood et al. (1991)	Physical fitness effects on substance abuse risk factors and use patterns	Wrong study design
Collingwood et al. (1994)	The use of a staff training model for implementing fitness programming to prevent substance abuse with at-risk youth	Wrong study design
Collingwood et al. (1997)	Effects of a staff training model for expanding physical activity programs within communities to prevent youth substance abuse	Wrong format

Collingwood et al. (2000)	Physical training as a substance abuse prevention intervention for youth	Wrong comparator
Collingwood et al. (1992)	Enlisting physical education for the war on drugs	Wrong study design
Crutzen et al. (2008)	Adolescents who intend to change multiple health behaviours choose greater exposure to an internet-delivered intervention	Wrong comparator
Cummings et al. (2014)	'All stars' for at-risk middle school students in an afterschool setting: A pilot program	Wrong intervention
D'Onofrio et al. (2002)	Curtailing tobacco use among youth: evaluation of project 4-health	Wrong intervention
Daley et al. (2004)	The effects of acute exercise on affective responses and desire to smoke in sedentary temporarily abstaining smokers: A preliminary study	Wrong format
Daniel et al. (2004)	Acute effects of a short bout of moderate versus light intensity exercise versus inactivity on tobacco withdrawal symptoms in sedentary smokers	Adult population
Donaghy (1997)	The investigation of exercise as an adjunct to the treatment and rehabilitation of the problem drinker	Adult population
Doumas et al. (2010)	Reducing heavy drinking among first year intercollegiate athletes: A randomized controlled trial of web-based normative feedback	Wrong intervention
Elder et al. (2002)	Tobacco and alcohol use–prevention program for Hispanic migrant adolescents	Wrong intervention
Elder et al. (1994)	Catch: Process evaluation of environmental factors and programs	Wrong study design
Elliot et al. (2004)	Preventing substance use and disordered eating: Initial outcomes of the ATHENA (Athletes Targeting Healthy Exercise and Nutrition Alternatives) program.	Wrong patient population
Elliot et al. (2006)	Definition and outcome of a curriculum to prevent disordered eating and body-shaping drug use.	Wrong patient population
Elliot et al. (2008)	Long-term outcomes of the ATHENA (Athletes Targeting Healthy Exercise & Nutrition Alternatives) program for female high school athletes.	Wrong patient population\
Ranby et al. (2009)	A mediation analysis of the ATHENA intervention for female athletes: Prevention of athletic-enhancing substance use and unhealthy weight loss behaviors	Wrong patient population
Epton et al. (2014)	A theory-based online health behaviour intervention for new university students (u@uni): Results from a randomised controlled trial	Wrong patient population
Fardy et al. (1996)	Coronary disease risk factor reduction and behavior modification in minority adolescents: The path program	Wrong patient population
Filion et al. (2015)	Examining the influence of a text message-based sleep and physical activity intervention among young adult smokers in the United States	Wrong intervention
Fisher et al. (1996)	Effect of a program of physical conditioning on high school girls who are smokers and non-smokers	Wrong format
Flay et al. (2004)	Effects of 2 prevention programs on high-risk behaviors among African American youth: aArandomized trial	Wrong intervention
Flores (1995)	Dance for health: Improving fitness in African American and Hispanic adolescents	Wrong outcomes

Gaihre et al. (2018)	Effect of add-on yoga on cognitive functions among substance abusers in a residential therapeutic center: Randomized comparative study	Wrong outcomes
Gary (1972)	The effect of jogging on physical fitness and self-concept in hospitalized alcoholics	Adult population
Goldberg et al. (1996)	Effects of a multidmensional anabolic steroid prevention intervention: The Adolescents Training and Learning to Avoid Steroids (ATLAS) program	Wrong patient population
Goldberg et al. (1996)	The Adolescents Training and Learning to Avoid Steroids (ATLAS) prevention program: Background and results of a model intervention.	Wrong patient population
Goldberg et al. (1996)	The adolescents training and learning to avoid steroids program: Preventing drug use and promoting health behaviors	Wrong patient population
Hall (1990)	Chemical health: Drug-prevention programs for athletes deter use of chemicals significantly	Wrong format
Helgadóttirn et al. (2018)	Sticking with it? Factors associated with exercise adherence in people with mild to moderate depression	Adult population
Hickmann (1994)	Research briefs... say yes to sports and no to tobacco: a fun and effective community outreach program for high risk youth in San Diego	Wrong comparator
Hill (1985)	Effect of a program of aerobic exercise on the smoking behaviour of a group of adult volunteers	Adult population
Hilyer (1982)	Physical fitness training and counseling as treatment for youthful offenders	Wrong outcomes
Hodkins (2004)	Adolescent weight gain during supervised substance abuse treatment: An examination of two interventions selected as possible solutions to the problem	Wrong format
Hutchinson et al. (2012)	Improving adolescent health through school-based health centers in post-Katrina New Orleans	Wrong intervention
Hynes (1989)	A school-based smoking prevention program for adolescent girls in New York City	Wrong format
Ivers et al. (2006)	Evaluation of a multi-component community tobacco intervention in three remote Australian Aboriginal communities	Wrong population
Janse Van Rensburg et. Al (2009)	Acute exercise modulates cigarette cravings and brain activation in response to smoking-related images: An FMRI study	Adult population
Jeffries et al. (2020)	The acute impact of hatha yoga on craving among smokers attempting to reduce or quit	Adult population
Jun et al. (2014)	A community-based multilevel intervention for smoking, physical activity and diet: Short-term findings from the community interventions for health programme in Hangzhou, China	Adult population
Keane et al. (2016)	Exploration of sedentary behavior in residential substance abuse populations: Results from an intervention study	Wrong population
Kelishadi et al. (2011)	Short-term results of a community-based program on promoting healthy lifestyle for prevention and control of chronic diseases in a developing country setting: Isfahan healthy heart program	Adult population
Kelly et al. (2019)	Healthy recovery: A pilot study of a smoking and other health behavior change intervention for people attending residential alcohol and other substance dependence treatment	Adult population

Khalsa et al. (2008)	Evaluation of a residential kundalini yoga lifestyle pilot program for addiction in India	Adult population
Kinnunen et al. (2008)	Exercise as an adjunct to nicotine gum in treating tobacco dependence among women	Wrong patient population
Knopf (2016)	Participation in sports reduces risk of teen rx opioid abuse	Wrong format
Kolovelonis et al. (2016)	Examining the effectiveness of the smoking prevention program "I do not smoke, I exercise" in elementary and secondary school settings	Wrong comparator
Kristjansson et al. (2010)	Adolescent substance use, parental monitoring, and leisure-time activities: 12-year outcomes of primary prevention in Iceland	Wrong intervention
Li et al. (2002)	Use of qigong therapy in the detoxification of heroin addicts	Adult population
Lindsey et al. (2012)	A gender-specific approach to improving substance abuse treatment for women: The healthy steps to freedom program	Adult population
Logsdon et al. (1989)	The feasibility of behavioral risk reduction in primary medical care	Adult population
Luepker et al. (1991)	The Minnesota heart health program: Education for youth and parents	Wrong format
Marcus et al. (1999)	The efficacy of exercise as an aid for smoking cessation in women: A randomized controlled trial	Adult population
Marcus et al. (1995)	Exercise enhances the maintenance of smoking cessation in women	Adult population
Marcus et al. (2005)	The efficacy of moderate-intensity exercise as an aid for smoking cessation in women: A randomized controlled trial	Adult population
Marcus et al. (2003)	Rationale, design, and baseline data for commit to quit ii: an evaluation of the efficacy of moderate-intensity physical activity as an aid to smoking cessation in women	Adult population
Martin et al. (1997)	Prospective evaluation of three smoking interventions in 205 recovering alcoholics: One-year results of project scrap-tobacco	Wrong patient population
Mathews et al. (2007)	An impact evaluation of two versions of a brief intervention targeting alcohol use and physical activity among adolescents	Wrong patient population
Melnyk et al. (2013)	Promoting healthy lifestyles in high school adolescents: a randomized controlled trial	Wrong intervention
Mikhail (1983)	The acute effects of aerobic exercise on cigarette smoking	Wrong format
Moore et al. (2012)	Pilot of a computer-based brief multiple–health behavior intervention for college students	Wrong study design
Morton et al. (2016)	Boxing clever: Utilizing education and fitness to build recovery capital in a substance use rehabilitation program	Adult population
Muller et al. (2015)	Group exercise to improve quality of life among substance use disorder patients	Adult population
Mustafaoglu et al. (2019)	Effects of core stabilization exercises on pulmonary function, respiratory muscle strength, and functional capacity in adolescents with substance use disorder: Randomized controlled trial	Wrong intervention
Nader et al. (1999)	Three-year maintenance of improved diet and physical activity: The catch cohort child and adolescent trial for cardiovascular health	Wrong patient population
Okruhlica et al. (2001)	Sports activities in the prevention of heroin dependency	Wrong intervention

Osilla et al. (2007)	Regular tobacco use among American Indian and Alaska native adolescents: an examination of protective mechanisms	Wrong intervention
Owen (1982)	The effect of a physical conditioning program on physical fitness and health locus of control among adolescent substance abusers	Wrong format
Palmer et al. (1995)	Effects of type of exercise on depression in recovering substance abusers	Adult population
Palmer et al. (1988)	Adult inpatient alcoholics: physical exercise as a treatment intervention	Adult population
Patten et al. (2017)	supervised, vigorous intensity exercise intervention for depressed female smokers: a pilot study	Adult population
Prapavessis et al. (2007)	The effects of exercise and nicotine replacement therapy on smoking rates in women	Adult population
Prapavessis et al. (2016)	Exercise to enhance smoking cessation: the getting physical on cigarette randomized control trial	Adult population
Prochaska et al. (2008)	Physical activity as a strategy for maintaining tobacco abstinence: a randomized trial	Wrong patient population
Rawson et al. (2015)	impact of an exercise intervention on methamphetamine use outcomes post-residential treatment care	Adult population
Reddy et al. (2014)	The effect of a yoga intervention on alcohol and drug abuse risk in veteran and civilian women with posttraumatic stress disorder	Adult population
Roessler et al. (2010)	Exercise treatment for drug abuse: A Danish pilot study	Adult population
Roessler et al. (2017)	Exercise as adjunctive treatment for alcohol use disorder: A randomized controlled trial	Adult population
Russell et al. (1988)	The effects of physical activity as maintenance for smoking cessation	Adult population
Saraf et al. (2015)	Effectiveness of a school-based intervention for prevention of non-communicable diseases in middle school children of rural north India: A randomized controlled trial	Wrong setting
Schinke et al. (2009)	Computer-delivered, parent-involvement intervention to prevent substance use among adolescent girls	Wrong intervention
Sevil et al. (2019)	can high schools be an effective setting to promote healthy lifestyles? effects of a multiple behavior change intervention in adolescents	Wrong outcomes
Sidhu et al. (2016)	Project ex-India: A classroom-based tobacco use prevention and cessation intervention program	Wrong intervention
Sinyor et al. (1982)	The role of a physical fitness program in the treatment of alcoholism	Adult population
Stölzel et al. (2014)	Be smart against cancer! A school-based program covering cancer-related risk behavior	Wrong patient population
Suchert et al. (2015)	Prospective effects of pedometer use and class competitions on physical activity in youth: a cluster-randomized controlled trial	Wrong outcomes
Tritter et al. (2015)	The effect of acute exercise on cigarette cravings while using a nicotine lozenge	Adult population
Ussery (2016)	Investigating the relation between physical activity and cigarette smoking: A longitudinal analysis from the United States and a pilot test of a structured afterschool program in Uruguay	Wrong format

Ussher et al. (2003)	Efficacy of exercise counselling as an aid for smoking cessation: A randomized controlled trial	Adult population
Ussher et al. (2015)	Physical activity for smoking cessation in pregnancy: Randomised controlled trial	Adult population
Ussher et al. (2006)	Acute effect of isometric exercise on desire to smoke and tobacco withdrawal symptoms	Adult population
Ussher et al. (2007)	Randomized controlled trial of physical activity counseling as an aid to smoking cessation: 12 month follow-up	Adult population
Van Rensburg et al. (2009)	The effects of acute exercise on attentional bias towards smoking-related stimuli during temporary abstinence from smoking	Adult population
Vasquez et al. (2004)	Effects of an experiential-based prevention education program on alcohol, tobacco, and other drugs (atod) knowledge and social attitudes and skills of first-time offender, non-adjudicated adolescents. (Abstract)	Wrong study design
Vedamurthachar et al. (2006)	Antidepressant efficacy and hormonal effects of Sudarshan kriya yoga (sky) in alcohol dependent individuals	Adult population
Velicer et al. (2013)	Multiple behavior interventions to prevent substance abuse and increase energy balance behaviors in middle school students	Wrong patient population
Vogel et al. (2019)	Smoking cessation intervention trial outcomes for sexual and gender minority young adults	Wrong intervention
Walker et al. (2002)	Health promotion for adolescents in primary care: Randomised controlled trial	Wrong intervention
Walker et al. (1988)	Modification of risk factors for coronary heart disease: Five-year results of a school-based intervention trial	Wrong patient population
Wang et al. (2015)	Acute exercise ameliorates craving and inhibitory deficits in methamphetamine: An ERP study	Adult population
Wang et al. (2016)	Dose-response relationships between exercise intensity, cravings, and inhibitory control in methamphetamine dependence: An ERPS study	Adult population
Weinstock et al. (2008)	Exercise-related activities are associated with positive outcome in contingency management treatment for substance use disorders	Adult population
Weinstock et al. (2020)	Randomized clinical trial of exercise for nontreatment seeking adults with alcohol use disorder	Adult population
Werch et al. (2005)	A multihealth behavior intervention integrating physical activity and substance use prevention for adolescents	Wrong patient population
Werch et al. (2011)	Brief integrative multiple behavior intervention effects and mediators for adolescents	Wrong patient population
Werch et al. (2002)	A brief alcohol preventive intervention for student athletes (article condensed from Werch (2000): Effects of a brief alcohol preventive intervention for youth attending school sports physical examinations)	Wrong study design
Werch et al. (2000)	Effects of a brief alcohol preventive intervention for youth attending school sports physical examinations	Wrong intervention
Werch et al. (2008)	Brief image-based health behavior messages for adolescents and their parents	Wrong intervention
Werch et al. (2003)	A sport-based intervention for preventing alcohol use and promoting physical activity among adolescents	Wrong patient population

Wicki et al. (2018)	Outcome evaluation of ‘Cool and Clean’, a sports-based substance use prevention programme for young people in Switzerland	Wrong intervention
Wilkinson et al. (2012)	Evaluation of the 'healthy start to pregnancy' early antenatal health promotion workshop: A randomized controlled trial	Adult population
Williams et al. (2011)	Acute effects of moderate intensity aerobic exercise on affective withdrawal symptoms and cravings among women smokers	Adult population
Williams et al. (2012)	Moderate intensity exercise as an adjunct to standard smoking cessation treatment for women: A pilot study	Wrong patient population
Yager et al. (2019)	Body image outcomes in a replication of the ATLAS program in Australia	Wrong patient population

Updated search 2022:

Reference	Title	Reason for exclusion
Bendtsen et al. (2021)	Developing a Fitbit-supported lifestyle physical activity intervention for depressed alcohol dependent women	Protocol
Furzer et al. (2021)	Exercise is medicine... when you enjoy it: Exercise enjoyment, relapse prevention efficacy, and health outcomes for youth within a drug and alcohol treatment service	Wrong comparator
Ramos et al. (2022)	Project SUN: Pilot Study of a Culturally Adapted Smoking Cessation Curriculum for American Indian Youth	Wrong intervention
Schijven et al. (2021)	The effectiveness of an indicated prevention programme for substance use in individuals with mild intellectual disabilities and borderline intellectual functioning: Results of a quasi-experimental study	Wrong intervention
Vogel et al. (2021)	Smoking cessation, metabolic risk behaviors, and stress management over time in a sample of young adult smokers	Wrong intervention

Appendix A.6
Search strategy

PsycINFO:

Population:

S1 MM "Emerging Adulthood"

S2 MM "College Athletes" OR MM "Community College Students" OR MM "Junior College Students" OR MM "Students" OR MM "College Graduates" OR MM "College Students" OR MM "Graduate Students" OR MM "High School Graduates" OR MM "High School Students" OR MM "International Students" OR MM "Junior High School Students" OR MM "Middle School Students" OR MM "Postgraduate Students"

S3 MM "Early Adolescence"

S4 youth OR adolescen* OR "young adults" OR "young people" OR teenagers OR minors OR underage (free text terms)

S18 S1 OR S2 OR S3 OR S4

Intervention – terms for specific intervention of interest:

S5 MM "Physical Fitness"

S6 MM "Athletic Participation"

S7 MM "Physical Activity" OR MM "Exercise" OR DE "Exercise" OR DE "Aerobic Exercise" OR DE "Yoga"

S8 MM "Sports" OR MM "Baseball" OR MM "Basketball" OR MM "Extreme Sports" OR MM "Football" OR MM "Judo" OR MM "Martial Arts" OR MM "Professional Sports" OR MM "Soccer" OR MM "Swimming" OR MM "Tennis" OR MM "Weightlifting"

S14 exercise OR walking OR dance OR dancing OR cycling OR running OR yoga OR "physical movement" OR "physical activity" OR sports OR pilates (free text terms)

S19 S5 OR S6 OR S7 OR S8 OR S14

Intervention- general terms:

S9 MM "Psychiatric Hospitalization" OR MM "Family Intervention" OR MM "Group Intervention" OR MM "Alcohol Treatment" OR MM "Treatment" OR MM "Addiction

Treatment" OR MM "Detoxification" OR MM "Substance Use Treatment" OR MM "Adjunctive Treatment" OR MM "Counseling" OR MM "Institutionalization" OR MM "Intervention" OR MM "Mind Body Therapy" OR MM "Mindfulness-Based Interventions" OR MM "Movement Therapy" OR MM "Outpatient Treatment" OR MM "Rehabilitation" OR MM "Symptoms Based Treatment" OR MM "Video-Based Interventions" OR MM "Early Intervention" OR MM "School Based Intervention"

S10 MM "Involuntary Treatment"

S12 intervention OR therapy OR treatment OR program OR training OR counseling OR counselling OR prevention (free text terms)

S17 rct OR "random* control* trial" OR "cohort control" OR "case control" OR "controlled trial" (free text terms)

S20 S9 OR S10 OR S12 OR S17

Outcomes:

S11 DE "Marijuana Usage" OR DE "Tobacco Smoking" OR MM "Heroin Addiction" OR MM "Morphine Dependence" OR MM "Polydrug Abuse" OR MM "Alcohol Abuse" OR MM "Alcohol Intoxication" OR MM "Acute Alcoholic Intoxication" OR MM "Chronic Alcoholic Intoxication" OR DE "Alcohol Withdrawal" OR DE "Prescription Drug Misuse" OR MM "Substance Use Disorder" OR MM "Alcohol Use Disorder" OR MM "Cannabis Use Disorder" OR MM "Drug Abuse" OR MM "Drug Dependency" OR MM "Inhalant Abuse" OR MM "Opioid Use Disorder" OR MM "Tobacco Use Disorder" OR MM "Drug Addiction" OR MM "Alcohol Use Disorder" OR MM "Cannabis Use Disorder" OR MM "Inhalant Abuse" OR MM "Polydrug Abuse" OR MM "Drug Dependency" OR MM "Inhalant Abuse" OR MM "Glue Sniffing" OR MM "Opioid Use Disorder" OR MM "Heroin Addiction" OR MM "Morphine Dependence" OR MM "Tobacco Use Disorder" OR MM "Drug Addiction" OR MM "Drug Withdrawal"

S13 MM "Smoking Cessation" OR MM "Sobriety" OR MM "Binge Drinking" OR MM "Underage Drinking" OR MM "Alcohol Use Disorder" OR MM "Alcoholism" OR MM "Opiates" OR MM "Alcohol Drinking Patterns" OR MM "Drug Abstinence" OR MM "Smoking Cessation" OR MM "Sobriety" OR MM "Heroin Addiction" OR MM "Intravenous Drug Usage" OR MM "Marijuana Usage" OR MM "Prescription Drug Misuse" OR MM "Hashish" OR MM "Marijuana" OR MM "Codeine" OR MM "Heroin" OR MM "Methadone" OR MM "Morphine" OR MM "Alcohols" OR MM "Benzodiazepines" OR MM "Cannabis" OR MM "Designer Drugs" OR MM "Drug Usage" OR MM "Generic Drugs" OR MM "Hallucinogenic Drugs" OR MM "Hypnotic Drugs"

OR MM "Narcotic Drugs" OR MM "Nonprescription Drugs" OR MM "Performance Enhancing Drugs" OR MM "Prescription Drugs" OR MM "Sedatives" OR MM "Steroids" OR MM "Tranquilizing Drugs"

S15 MM "Crack Cocaine"

S16 “substance addiction" OR "substance misuse" OR "alcohol abuse" OR marihuana OR cannabis OR drinking OR "illicit drugs" OR "substance use" OR smoking (free text terms)

S21 S11 OR S13 OR S15 OR S16

Combined:

S22 S18 AND S19 AND S20 AND S21

Limiters: English; Age Groups: Adolescence (13-17 yrs), Young Adulthood (18-29 yrs)

MEDLINE:

Population:

S1 MM "Young Adult") OR (MM "Minors") OR (MM "Adolescent") OR (MM "Adolescent, Institutionalized") OR (MM "Adolescent, Hospitalized") OR (MM "Students")

S2 youth OR adolescen* OR "young adults" OR teenagers OR underage OR minors OR "young people" OR graduates (free text terms)

S3 S1 OR S2

Intervention – terms for specific intervention of interest:

S4 (MM "Exercise") OR (MM "Walking") OR (MM "Swimming") OR (MM "Running+") OR (MM "Gymnastics") OR (MM "Motor Activity") OR (MM "Movement") OR (MM "Sports+") OR (MM "Water Sports+") OR (MM "Snow Sports+") OR (MM "Racquet Sports+") OR (MM "Martial Arts+") OR (MM "Youth Sports") OR (MM "Wrestling") OR (MM "Volleyball") OR (MM "Track and Field") OR (MM "Soccer") OR (MM "Skating") OR (MM "Weight Lifting") OR (MM "Baseball") OR (MM "Basketball") OR (MM "Bicycling") OR (MM "Boxing") OR (MM "Cricket Sport") OR (MM "Football") OR (MM "Golf") OR (MM "Hockey") OR (MM "Mountaineering") OR (MM "Athletic Performance") OR (MM "Physical Fitness") OR (MM "Recreation") OR (MM "Dancing")

S5 sports OR "physical movement" OR cycling OR "physical activity" OR exercise OR yoga OR pilates (free text terms)

S6 S4 OR S5

Intervention- general terms:

S7 MM "Crisis Intervention") OR (MM "Dance Therapy") OR (MM "Internet-Based Intervention") OR (MM "Early Intervention, Educational") OR (MM "Exercise Therapy")

S8 intervention OR therapy OR treatment OR program OR training OR rehabilitation OR counselling OR counseling OR prevention (free text terms)

S9 rct OR "controlled trial" OR "random* control* trial" OR "cohort control" OR "case control" (free text terms)

S10 S7 OR S8 OR S9

Outcomes:

S11 (MM "Tobacco Use Disorder") OR (MM "Substance Abuse, Oral") OR (MM "Substance Abuse, Intravenous") OR (MM "Phencyclidine Abuse") OR (MM "Narcotic-Related Disorders") OR (MM "Marijuana Abuse") OR (MM "Inhalant Abuse") OR (MM "Drug Overdose") OR (MM "Cocaine-Related Disorders") OR (MM "Amphetamine-Related Disorders") OR (MM "Alcohol-Related Disorders") OR (MM "Binge Drinking") OR (MM "Alcoholism") OR (MM "Alcoholic Intoxication") OR (MM "Opioid-Related Disorders+") OR (MM "Opium Dependence") OR (MM "Morphine Dependence") OR (MM "Heroin Dependence") OR (MM "Chemically-Induced Disorders") OR (MM "Marijuana Use+") OR (MM "Alcohol Drinking") OR (MM "Tobacco Smoking") OR (MM "Tobacco Use+") OR (MM "Trema") OR (MM "Underage Drinking") OR (MM "Alcohol Drinking in College") OR (MM "Smokers") OR (MM "Drug Users") OR (MM "Drug Misuse+") OR (MM "Prescription Drug Misuse+") OR (MM "Prescription Drug Overuse")

S12 “substance addiction" OR "substance misuse" OR marihuana OR smoking OR drinking OR "substance use" OR "illicit drugs" (free text terms)

S13 S11 OR S12

Combined:

S14 S3 AND S6 AND S10 AND S13

Limiters: English Language; Age Related: Adolescent: 13-18 years, Young Adult: 19-24 years

CINAHL:

Population:

S1 (MM "Young Adult") OR (MM "Adolescence+") OR (MM "Minors (Legal)") OR (MM "Students") OR (MH "Students, College") OR (MM "Students, High School") OR (MM "Students, Middle School") OR (MM "High School Graduates") OR (MM "College Graduates")

S2 "emerging adulthood" OR adolescen* OR "young people" OR teenagers OR underage OR youth OR "young adults" OR minors OR underage (free text terms)

S3 S1 OR S2

Intervention – terms for specific intervention of interest:

S4 MM "Physical Activity") OR (MM "Physical Fitness") OR (MM "Exercise+") OR (MM "Walking") OR (MM "Dancing+") OR (MM "Sports") OR (MM "Amateur Sports") OR (MM "Horseback Riding") OR (MM "Aquatic Sports") OR (MM "Body Building") OR (MM "Bowling") OR (MM "College Sports") OR (MM "Caving") OR (MM "Contact Sports+") OR (MM "Cycling") OR (MM "Endurance Sports") OR (MM "Extreme Sports") OR (MM "Fencing") OR (MM "Golf") OR (MM "Gymnastics") OR (MM "Handball") OR (MM "Mountaineering") OR (MM "Race Walking") OR (MM "Racquet Sports") OR (MM "Running+") OR (MM "Rock Climbing") OR (MM "Skating+") OR (MM "Skiing+") OR (MM "Team Sports+") OR (MM "Target Sports") OR (MM "Track and Field") OR (MM "Triathlon") OR (MM "Weight Lifting") OR (MM "Winter Sports+") OR (MH "Animal Sports") OR (MM "Movement") OR (MM "Athletic Training Programs") OR (MM "Athletic Training")

S5 (MM "Tai Chi") OR (MM "Yoga")

S6 "physical activity" OR sports OR "physical movement" OR exercise OR pilates OR dance OR running OR walking (free text terms)

S7 S4 OR S5 OR S6

Intervention- general terms:

S8 (MM "Drug Rehabilitation Programs+") OR (MM "Alcohol Rehabilitation Programs") OR (MM "Substance Use Rehabilitation Programs") OR (MM "Early Intervention") OR (MH

"Alternative Therapies") OR (MM "Dance Therapy") OR (MM "Mind Body Techniques") OR (MM "Internet-Based Intervention")

S9 intervention OR treatment OR therapy OR counselling OR counseling OR rehabilitation OR program OR training OR prevention (free text terms)

S10 rct OR "case control" OR "random* control* trial" OR "cohort control" OR "controlled trial" (free text terms)

S11 S8 OR S9 OR S10

Outcomes:

S12 (MM "Substance Use Disorders+") OR (MM "Substance Dependence+") OR (MM "Substance Abuse+") OR (MM "Alcohol-Related Disorders") OR (MM "Binge Drinking") OR (MM "Smoking+") OR (MM "Alcohol Abuse") OR (MM "Alcoholic Intoxication") OR (MM "Alcoholism") OR (MM "Substance Abuse, Intravenous") OR (MM "Substance Abuse, Perinatal") OR (MM "Inhalant Abuse") OR (MM "Substance Withdrawal Syndrome+") OR (MM "Substance Abusers+") OR (MM "Designer Drugs") OR (MM "Drugs, Off-Label") OR (MM "Street Drugs+") OR (MM "Synthetic Drugs") OR (MM "Cannabis+")

S13 "substance addiction" OR "substance misuse" OR "alcohol abuse" OR marijuana OR marihuana OR "illicit drugs" OR "substance use" OR drinking OR cannabis (free text terms)

S14 S12 OR S13

Combined:

S15 S3 AND S7 AND S11 AND S14

Limiters: English Language; Age Groups: Adolescent: 13-18 years, Adult: 19-44 years

SportDiscus:

Population:

S1 DE "BOYS" OR DE "GIRLS" OR DE "TEENAGERS" OR DE "YOUNG adults" OR DE "YOUTH"

S2 DE "COLLEGE basketball players" OR DE "COLLEGE football players" OR DE "COMMUNITY college athletes" OR DE "MALE college athletes" OR DE "WOMEN

college athletes" OR DE "COLLEGE athletes" OR DE "UNDERGRADUATES" OR DE "WOMEN college students" OR DE "STUDENTS" OR DE "COLLEGE students"

S3 DE "HIGH school athletes" OR DE "HIGH school students"

S4 "young people" OR "young person" OR underage OR minors OR "emerging adults" OR "young adults" OR adolescen* (free text terms)

S5 S1 OR S2 OR S3 OR S4

Intervention – terms for specific intervention of interest:

S6 DE "CROSS-country (Horsemanship)" OR DE "HORSE archery" OR DE "POLOCROSSE" OR DE "SHOW jumping" OR DE "SHOW riding" OR DE "TRICK riding" OR DE "VAULTING (Horsemanship)" OR DE "HORSE sports" OR DE "BUDO" OR DE "EAST Asian martial arts" OR DE "ESCRIMA" OR DE "JEET Kune Do" OR DE "JU-kenpo" OR DE "KAJUKENBO" OR DE "KALARIPPAYATTU" OR DE "KENJUTSU" OR DE "KENPO" OR DE "KICKBOXING" OR DE "KRAV maga" OR DE "KUN-tao" OR DE "KYUDO (Archery)" OR DE "LION dance" OR DE "MARTIAL arts for children" OR DE "MARTIAL arts for people with disabilities" OR DE "MIXED martial arts" OR DE "NINJUTSU" OR DE "PENCAK silat" OR DE "SAN-jitsu" OR DE "SHISHIMAI (Dance)" OR DE "SPEAR fighting" OR DE "DUELING" OR DE "HAND-to-hand fighting" OR DE "ULTRAENDURANCE sports" OR DE "SURFING" OR DE "EXTREME skiing" OR DE "KITE surfing" OR DE "GYMNASTICS" OR DE "ACROBATICS" OR DE "ARTISTIC gymnastics" OR DE "CARTWHEELS" OR DE "GYMNASTICS for boys" OR DE "GYMNASTICS for children" OR DE "GYMNASTICS for girls" OR DE "GYMNASTICS for men" OR DE "GYMNASTICS for people with disabilities" OR DE "GYMNASTICS for women" OR DE "HANDSPRINGS" OR DE "HANDSTANDS" OR DE "HEADSTANDS" OR DE "PYRAMIDS (Gymnastics)" OR DE "SCHOOL exercises & recreations" OR DE "SOMERSAULTS" OR DE "SWEDISH gymnastics" OR DE "SWIMNASTICS" OR DE "TEAM aerobics" OR DE "TUMBLING" OR DE "TEAM aerobics" OR DE "TRAMPOLINES" OR DE "TUMBLING" OR DE "AERIAL dance" OR DE "HALF marathons (Running)" OR DE "MARATHON running" OR DE "OBSTACLE racing" OR DE "RIDE & tie racing" OR DE "ULTRAMARATHON running" OR DE "BAREFOOT running" OR DE "CROSS-country running" OR DE "GAIT in humans" OR DE "JOGGING" OR DE "LONG-distance running" OR DE "MIDDLE distance running" OR DE "MINIMALIST running" OR DE "ROAD running" OR DE "RUNNING for children" OR DE "RUNNING for older people" OR DE "RUNNING for people with disabilities"

OR DE "SPRINTING" OR DE "STREAKERS & streaking" OR DE "TRAIL running" OR DE "WATER aerobics" OR DE "AEROBIC exercises" OR DE "AQUATIC exercises" OR DE "CIRCUIT training" OR DE "EXERCISE for girls" OR DE "EXERCISE for men" OR DE "EXERCISE for women" OR DE "HATHA yoga" OR DE "KNEE exercises" OR DE "PILATES method" OR DE "QI gong" OR DE "RUNNING" OR DE "STRENGTH training" OR DE "TAI chi" OR DE "TREADMILL exercise" OR DE "YOGA" OR DE "EXERCISE for youth" OR DE "PHYSICAL fitness for girls" OR DE "PHYSICAL fitness for teenage girls" OR DE "PHYSICAL fitness for youth" OR DE "MARTIAL arts" OR DE "BICYCLE racing" OR DE "CAMEL racing" OR DE "CANOE racing" OR DE "DRAGON boat racing" OR DE "GONDOLA racing" OR DE "HORSE racing" OR DE "HURDLING (Track & field)" OR DE "RUNNING races" OR DE "SKATING races" OR DE "SKI racing" OR DE "SLALOM racing" OR DE "SPEED skating" OR DE "HIGH school baseball" OR DE "HIGH school basketball" OR DE "HIGH school football" OR DE "HIGH school soccer" OR DE "HIGH school volleyball" OR DE "HIGH school wrestling" OR DE "AFTER school sports" OR DE "FREE skating" OR DE "IN-line skating" OR DE "MOUNTAINBOARDING" OR DE "ORIGINAL set pattern dance (Skating)" OR DE "PAIR roller skating" OR DE "ROLLER derby" OR DE "ROLLER polo" OR DE "SKATEBOARDING" OR DE "STREET luge racing" OR DE "ROLLER hockey" OR DE "BASKETBALL for girls" OR DE "BOWLING for girls" OR DE "FIELD hockey for girls" OR DE "FIGURE skating for girls" OR DE "GYMNASTICS for girls" OR DE "HOCKEY for girls" OR DE "LACROSSE for girls" OR DE "RINGETTE (Game)" OR DE "RUGBY football for girls" OR DE "SCHOOL sports for girls" OR DE "SOCCER for girls" OR DE "TENNIS for girls" OR DE "VOLLEYBALL for girls" OR DE "BASEBALL" OR DE "BASKETBALL" OR DE "BATTLE ball" OR DE "CRICKET (Sport)" OR DE "DODGEBALL" OR DE "GOALBALL" OR DE "HOCKEY" OR DE "KICKBALL" OR DE "LACROSSE" OR DE "NATIVE American stickball" OR DE "POLO" OR DE "PUSH ball" OR DE "QUIDDITCH (Game)" OR DE "RUGBALL" OR DE "RUGBY football" OR DE "SOCCER" OR DE "SOFTBALL" OR DE "SPEEDBALL" OR DE "STOOLBALL" OR DE "TCHOUKBALL" OR DE "TETHERBALL" OR DE "VOLLEYBALL" OR DE "WALLYBALL" OR DE "POLO" OR DE "SPEEDBALL" OR DE "TCHOUKBALL" OR DE "TETHERBALL" OR DE "VOLLEYBALL" OR DE "WALLYBALL" OR DE "WIFFLE ball" OR DE "BIATHLON" OR DE "BOBSLEDDING" OR DE "BROOMBALL" OR DE "COASTING (Winter sports)" OR DE "CURLING" OR DE "NORDIC combined" OR DE "PARASKIING" OR DE "SKATE sailing" OR DE "SKATING" OR DE "SKIBOARDING" OR DE "SKIS & skiing" OR DE "SLEDDING" OR DE "SNOW golf"

OR DE "SNOW skating" OR DE "SNOWBOARDING" OR DE "TOBOGGANING" OR DE "WOMEN'S sports" OR DE "WOMEN'S baseball" OR DE "WOMEN'S basketball" OR DE "WOMEN'S bodybuilding" OR DE "WOMEN'S boxing" OR DE "WOMEN'S college sports" OR DE "WOMEN'S cricket" OR DE "WOMEN'S cycling" OR DE "WOMEN'S diving" OR DE "WOMEN'S fencing" OR DE "WOMEN'S field hockey" OR DE "WOMEN'S flag football" OR DE "WOMEN'S golf" OR DE "WOMEN'S handball" OR DE "WOMEN'S hiking" OR DE "WOMEN'S hockey" OR DE "WOMEN'S in-line skating" OR DE "WOMEN'S judo" OR DE "WOMEN'S lacrosse" OR DE "WOMEN'S rowing" OR DE "WOMEN'S rugby football" OR DE "WOMEN'S running" OR DE "WOMEN'S sea kayaking" OR DE "WOMEN'S skiing" OR DE "WOMEN'S snowboarding" OR DE "WOMEN'S soccer" OR DE "WOMEN'S softball" OR DE "WOMEN'S speed skating" OR DE "WOMEN'S speedball" OR DE "WOMEN'S surfing" OR DE "WOMEN'S swimming" OR DE "WOMEN'S tennis" OR DE "WOMEN'S track & field" OR DE "WOMEN'S volleyball" OR DE "WOMEN'S water polo" OR DE "WOMEN'S weight training" OR DE "WOMEN'S wrestling" OR DE "SPORTS" OR DE "ANIMAL sports" OR DE "AQUATIC sports" OR DE "BALL games" OR DE "BASEBALL" OR DE "COLLEGE sports" OR DE "COMBAT sports" OR DE "CONTACT sports" OR DE "CROSS-training (Sports)" OR DE "DISC golf" OR DE "ENDURANCE sports" OR DE "EXTREME sports" OR DE "GAELIC games" OR DE "GYMNASTICS" OR DE "HOCKEY" OR DE "INDIVIDUAL sports" OR DE "MILITARY sports" OR DE "PARKOUR" OR DE "RECREATIONAL sports" OR DE "RODEOS" OR DE "ROLLER skating" OR DE "SCHOOL sports" OR DE "SOFTBALL" OR DE "SPORTS for girls" OR DE "SPORTS for people with disabilities" OR DE "SPORTS for youth" OR DE "TEAM sports" OR DE "WINTER sports" OR DE "ATHLETICS" OR DE "EXERCISE”

S7 DE "PHYSICAL fitness for teenage girls" OR DE "AMATEUR sports" OR DE "BAG punching" OR DE "BOXING" OR DE "COLLEGE sports" OR DE "DUATHLON" OR DE "FENCING" OR DE "HIGHLAND games" OR DE "POWERLIFTING" OR DE "SWIMMING" OR DE "TETRATHLON" OR DE "TRACK & field" OR DE "TRIATHLON" OR DE "WALKING" OR DE "WEIGHT lifting" OR DE "WRESTLING" OR DE "BODYBUILDING" OR DE "PHYSICAL fitness for girls" OR DE "PHYSICAL fitness for men" OR DE "PHYSICAL fitness for people with disabilities" OR DE "PHYSICAL fitness for women" OR DE "PHYSICAL fitness for youth" OR DE "ATHLETICS" OR DE "CALISTHENICS" OR DE "CIRCUIT training" OR DE "EXERCISE for girls" OR DE "QI gong" OR DE "PHYSICAL activity" OR DE "PHYSICAL fitness" OR DE "SPORTS"

S8 DE "INTRAMURAL sports" OR DE "SCHOOL exercises & recreations" OR DE "STUDENT recreation" OR DE "SKIS & skiing" OR DE "PRACTICE (Sports)" OR DE "PHYSICAL training & conditioning"

S9 dance OR "physical activity" OR exercise OR cycling OR "physical movement" OR dancing OR running (free text terms)

S10 S6 OR S7 OR S8 OR S9

Intervention- general terms:

S11 DE "DANCE therapy" OR DE "REHABILITATION" OR DE "THERAPEUTICS" OR DE "TREATMENT programs" OR DE "ALCOHOLISM treatment" OR DE "DETOXIFICATION (Substance abuse treatment)" OR DE "DRUG abuse treatment" OR DE "SUBSTANCE abuse treatment"

S12 DE "MOVEMENT therapy" OR DE "DRUG abuse treatment" OR DE "SWIMMING therapy" OR DE "EXERCISE therapy" OR DE "RIDING therapy" OR DE "PREVENTION"

S13 intervention OR therapy OR treatment OR program OR training OR rehabilitation OR counselling OR counseling OR prevention (free text terms)

S14 rct OR "cohort control" OR "controlled trial" OR "random* control* trial" OR "case control" (free text terms)

S15 S11 OR S12 OR S13 OR S14

Outcomes:

S16 DE "ALCOHOL" OR DE "ALCOHOL drinking" OR DE "PAINT sniffing" OR DE "ALCOHOLICS" OR DE "DRUG addicts" OR DE "MEDICATION abusers" OR DE "ALCOHOLISM" OR DE "DRUG abuse" OR DE "INHALANT abuse" OR DE "DRUG withdrawal symptoms" OR DE "SUBSTANCE abuse" OR DE "NICOTINE addiction" OR DE "ADDICTS" OR DE "TOBACCO use" OR DE "CIGARETTE smokers" OR DE "CIGARETTES" OR DE "SMOKING" OR DE "SMOKING cessation" OR DE "YOUNG adults -- Tobacco use" OR DE "YOUTH -- Tobacco use"

S17 DE "DRUG abusers" OR DE "DRUG addicts" OR DE "INTRAVENOUS drug abusers"

S18 DE "DETOXIFICATION (Substance abuse treatment)"

S19 DE "OPIOIDS" OR DE "BARBITURATES" OR DE "METHYLPHENIDATE" OR DE "CANNABIS" OR DE "MARIJUANA abuse" OR DE "COCAINE" OR DE "HEROIN" OR DE "MORPHINE" OR DE "OXYCODONE" OR DE "DRUG abuse" OR DE

"HASHISH" OR DE "MARIJUANA" OR DE "NARCOTICS" OR DE "PSYCHIATRIC drugs" OR DE "SEDATIVES" OR DE "STIMULANTS" OR DE "AMPHETAMINES" OR DE "METHAMPHETAMINE" OR DE "AMPHETAMINE abuse" OR DE "DRUGS of abuse"

S20 marihuana OR "illicit drugs" OR drinking OR "substance addiction" OR "substance misuse" OR "alcohol abuse" OR "substance use" OR cannabis (free text terms)

S21 S16 OR S17 OR S18 OR S19 OR S20

Combined:

S22 S5 AND S10 AND S15 AND S21

Limiters: Language: English

Appendix A.7

Detailed implementation characteristics of Publication 3

Supplementary Table 1

Detailed implementation characteristics of included studies

Reference	Implementation strategies	Implementation barriers	Implementation fidelity	Personnel acceptance
An et al. (2013)	- Weekly coach meetings. - Partly monitored video messages/phone calls. - Peer training: Training in motivational interviewing by counseling supervisor to ensure adherence of peers to protocols.	Not specified	Not specified	Not specified
Correia, Benson, and Carey (2005)	Not specified	Not specified	Not specified	Not specified
Daniel, Cropley, and Fife-Schaw (2007)	Not specified	Not specified	Not specified	Not specified
Daniel, Cropley, and Fife-Schaw (2006)	Not specified	Not specified	Not specified	Not specified
E. S. Everson, Daley, and Ussher (2006)	Not specified	Not specified	Not specified	Not specified
Emma S. Everson, Daley, and Ussher (2008)	Not specified	Not specified	Not specified	Not specified
Faulkner, Arbour-Nicitopoulos, and Hsin (2010)	Not specified	Not specified	Not specified	Not specified
Fishbein et al. (2016)	- Implementation in small environment with personal support and community-based learning. - Teacher tasks balanced across teachers to minimize burden for teachers. - Consultation of expert clinical panel with implementation knowledge and experience regarding nontraditional schools.	- Securing support for study from school staff - Minimizing study burden on school staff.	Not specified	Not specified
Ho et al. (2014)	Not specified	Not specified	Not specified	Not specified
Blank et al. (2017); Horn et al. (2013); Horn et al. (2011)	- Facilitator training: Facilitators identified by school staff/principals. - Condition-specific training provided by American Lung Association West Virginia and researchers. - N-O-T facilitator training: 1.5 days with focus on protocol. - BI training: 3 hours with focus on research protocol.	Not specified	Not specified	Not specified

Kerr et al. (2013)	Standardized curriculum training for facilitators.	Not specified	- Curriculum fidelity: Curriculum correctly implemented at 95% of sessions. - Fidelity assessment: 65% of curriculum sessions observed/ scored	Not specified
Lane, Lindemann, and Schmidt (2012)	Not specified	Not specified	Not specified	Not specified
Melamed et al. (2022)	- NAVIGATE modules transferred into online format. - Training for health coaches in cognitive behavioral therapy (CBT) or motivational interviewing (MI). - Weekly supervision of coaches by registered psychotherapist. - Virtual care team to review client's progression. - Use of a collaborative care model to overcome fragmentation barriers in mental health and primary care services. - Technology-enabled collaborative care (TECC) model to overcome barriers such as geographical barriers, time pressure and competing demands for the attention of providers. - Client communication limited to only one person (health coach) instead of entire healthcare team.	Not specified	- E-platform collected program use metrics to measure participant e-platform use and health coaching services	Not specified
Murphy, Pagano, and Marlatt (1986)	Not specified	Not specified.	Not specified	Not specified
Oh and Taylor (2014)	Not specified	Not specified	Not specified	Not specified
Parker et al. (2016)	- Allocation to therapists according to their workload and availability. - Implementation directly into established youth mental health clinical services. - Intervention duration adapted to insurance funding for psychological therapies.	Not specified	- - Over 60% of participants received at least 3 sessions. - High fidelity of interventions as study was directly implemented in youth mental health clinical services and did not require access to specialized exercise equipment or off-site facilities.	Not specified
Prapavessis et al. (2014)	Not specified	Not specified	Not specified	Not specified
Prince, Collins, Wilson, and Vincent (2020)	- Use of smartphones as convenient and functional tools: Two-way functionality of smartphones allows interactions between, researchers/ clinicians/ clients/ participants.	Not specified	Not specified	Not specified
M. Rotheram-Borus et al. (2016)	- Training for soccer coaches: Training in HIV/substance abuse preventive interventions, trained in fundamental of behavior change. - Continuous monitoring and supervision from Stellenbosch University and Grassroot soccer (organization that implements soccer-based HIV prevention interventions across sub-Saharan Africa) to ensure correct implementation, support and	- Challenging local, political situations and context. - Gains in risk reduction challenged in the context of national unrest/job strikes.	High fidelity.	Not specified

	fast and effective identification and elimination of any issues/concerns. - Monthly supervision meetings for coaches. - Community setting rather than medical setting. - Implementation of interventions within activities with sustainable funding stream (e.g., FIFA) Soccer/vocational training as sites for HIV services.			
Scott and Myers (1988)	Not specified	Not specified	Not specified	Not specified
Stanley, Asfour, Weitzman, and Sherman (2017)	- Self-sustaining model: Peer to peer education model (University students can teach high school students at no cost). - Student teachers as agents of change in their own communities.	Cultural setting of United Arab Emirates.	Not specified	Not specified
Janse Van Rensburg and Taylor (2008)	Not specified	Not specified	Not specified	Not specified
A. Taylor, Katomeri, and Ussher (2006); A. H. Taylor, Katomeri, and Ussher (2005)	Not specified	Not specified	Not specified	Not specified
Tesler, Plaut, and Endvelt (2018)	- Implementation directly into established youth advancement center. - Shared resources of multiple expert organizations and municipality resulted in more comprehensive/widespread program.	Not specified	Not specified	Not specified
Jeremiah Weinstock, Capizzi, Weber, Pescatello, and Petry (2014)	Not specified.	Not specified	Not specified	Not specified
Jeremiah Weinstock, Petry, Pescatello, and Henderson (2016)	- Facilitator training: Workshop on MI and CM by outside expert, annual one-day refresher - Continuous supervision: Regular review of intervention binders/ audiotapes/ case discussion.	Not specified	- Fidelity assessed by 6 independent raters. - 127 randomly selected audiotapes assessed. - MI, EC, and CM items rated on a 7- point Likert scale. - Outcome: Interventions were rated as having good therapist adherence/ competence.	Good
Wilson, Collins, Prince, and Vincent (2018)	Not specified	Not specified	Not specified	Not specified
(Ybarra et al., 2013)	- Technological feasibility of program tested prior to study start. Findings of feasibility testing were fed back into the program. - Involvement of youth advisory groups in intervention development.	Not specified	Good	Not specified

APPENDIX B

Appendices from Chapter 4, Phase 2, Quantitative Online Survey

Young People's Expertise: A Mixed Methods Exploration

Appendix B.1

Participant information online survey

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate in this research project entitled: **Integration of physical activity in young people's substance use treatment provided by Australian clinical services.**

This survey is part of a project conducted by Prof Alex Parker (Chief investigator), Prof Melinda Craike (Associate Investigator), A/Prof Gill Bedi (Associate Investigator), Dr. Susan Kidd (Associate Investigator) and Lee Klamert (Student Investigator) from the Institute for Health and Sport, Victoria University.

Purpose and background
Although research has demonstrated the benefits of physical activity on mental health and substance use, physical activity is rarely included in existing treatments to manage mental health and substance use problems. Some young people experience barriers regarding physical activity participation, for example limited access to exercise facilities.

This survey aims to explore these experienced barriers and the acceptability of integrating physical activity into existing mental health and substance use treatment.

What will I be asked to do?
You will be asked to complete an online survey. Completing the survey is voluntary and while encouraged to answer all questions, you can choose not to respond to any questions or not complete the survey. The information you provide will be completely anonymous and securely stored.

You can choose to opt-in to a draw to win one of 20 $50 gift vouchers to thank you for your participation. If you choose to opt-in, you will be forwarded to a different site asked to provide your name and address. Your name and address will be collected separately and independently to your survey participation. This ensures that your survey participation will stay anonymous.

What will I gain from participating?
You will not gain immediate benefits from your participation, as this research is in its early stages. However, by completing the survey, you will contribute to understanding the treatment preferences and barriers to physical activity participation experienced by young people with mental health concerns and substance use. This is crucial to improve existing health services and develop physical activity-based programs that are acceptable and satisfying to young people.

What are the potential risks of participating in this study?
There is a low risk of psychological distress associated with survey questions that investigate potentially sensitive topics, including mental health. If you feel any distress related to the research project, several resources will be provided for you to contact.

How will the information I give be used?
Your survey data will be anonymous and will be used for research purposes in scientific and public health related publications (e.g. journals, research reports, and conference presentations). In these publications all data will be summarised and aims to provide guidance on how physical activity can be used in youth mental health and substance use services.

If you are willing to participate you will be asked give consent to a digital consent form on the following page by clicking on the respective survey button.

How will this survey be conducted?
As part of the survey, you will be asked about your mental health, substance use, physical activity level, your experienced benefits and barriers to physical activity participation and your preferences if physical activity was included in existing health services.

Who is conducting the survey?
The Institute for Health and Sport (iHeS), Victoria University

Any queries about your participation in this project may be directed to the Chief Investigator.

Chief Investigator:
Professor Alex Parker
Institute for Health and Sport (iHeS), Victoria University
Phone: +61 3 9919 5874 or 0466 027 803
Email: Alex.Parker@vu.edu.au

Other investigators:
Prof Melinda Craike (Victoria University), Ass/Prof Gill Bedi (Orygen Youth Mental Health), Dr Susan Kidd (NSW Health), Lisa (Lee) Klamert (PhD candidate, Victoria University).

If you require support as a consequence of your participation in the study, you will be able to access psychological services through the following resources:

- Lifeline Australia: 13 11 14
- Beyond Blue: 1300 22 4636
- Counselling Online: 1800 888 236
- Headspace: 1800 650 890
- Kids Helpline: 1800 55 1800
- National Alcohol and Other Drug Hotline: 1800 250 015
- DirectLine: 1800 888 236

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

Appendix B.2

Informed consent online survey

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

We would like you to be part of the research project called "**Integration of physical activity in young people's substance use and mental health treatment provided by Australian clinical services"** conducted by Prof. Alex Parker (Chief Investigator), Prof Melinda Craike (Associate Investigator), A/Prof Gill Bedi (Associate Investigator), Dr. Susan Kidd (Associate Investigator) and Lee Klamert (Student Investigator) from the Institute for Health and Sport, Victoria University.

You are invited to complete a survey to explore young people's physical activity engagement, substance use, mental health, and preferences regarding the integration of physical activity into existing health services for young people wanting to reduce their substance use and improve their mental health.

There is a low risk of psychological distress related to any potentially sensitive topics asked about as part of the survey.

CERTIFICATION BY PARTICIPANT

I certify that I am at least 16 years old* and that I freely agree to participate in the survey, including questions on:

- Substance use and physical activity behaviour
- Mental health and well-being
- Preferences regarding substance use and physical activity-based treatments
- Experienced barriers regarding physical activity participation

I have read and I understand the participant information on the previous page.
I have had the opportunity to have make an informed decision about my survey participation and I understand that I can withdraw from this survey at any point up until the data has been analysed. At this time, the data will be merged with others, and it will not be possible to withdraw my data.
I certify that the purpose of the survey, together with any risks and safeguards associated with participation, have been fully explained to me on the previous page.
I have been informed that the information I provide is completely anonymous and cannot be associated with my name or person.
By moving on to the next page I consent to participating in this survey.

Queries and complaints:
Any queries about your participation in this project may be directed to the Chief Investigator Professor Alex Parker. Phone: +61 3 9919 5874 or 0466 027 803 (during business hours). Email: Alex.Parker@vu.edu.au

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

Appendix B.3

Online survey questions

1. Study information

2. Informed consent

3. Consent check

1. Am I participating in this study voluntarily?
    - I am not participating voluntarily in this survey and I am expected to complete this survey.
    - I am participating voluntarily in this survey and it is perfectly okay to not agree to participate or to quit in the middle of it. (Correct response)
    - I am participating in this survey voluntarily; however, it is not okay to quit in the middle of it once started.
    - I am not participating in this survey voluntarily and if I quit or decide not to participate it would affect my relationship with the university.
2. Which of the following is correct?
    - My answers are anonymous, and there is a small chance that I could feel some discomfort while answering the survey questions. (Correct response)
    - My answers are anonymous, and there is a moderate chance that I could feel some discomfort while answering the survey questions.
    - My answers are not anonymous, and there is is a small chance that I could feel some discomfort while answering the survey questions.
    - My answers are not anonymous, and there is a moderate chance that I could feel some discomfort while answering the survey questions.

4. List of Victorian support resources

We do not expect that participating in this survey will cause distress. However, if you experience any concerns or feelings of distress, please reach out to one of the following Victorian support services:

- Lifeline Australia: 13 11 14
- Beyond Blue: 1300 22 4636
- Counselling Online: 1800 888 236
- Headspace: 1800 650 890
- Kids Helpline: 1800 55 1800
- National Alcohol and Other Drug Hotline: 1800 250 015
- DirectLine: 1800 888 236

5. Screening Tests

5.1. Screening question on age

Please indicate your age.

- Younger than 16 years of age
- Between 16 and 25 years of age
- Older than 25 years of age

5.2. WHO ASSIST

The following questions ask about your experience of using alcohol, tobacco products and other drugs across your lifetime and in the past three months. These substances can be smoked, swallowed, snorted, inhaled or injected (show response card).

Some of the substances listed may be prescribed by a doctor (like amphetamines, sedatives, pain medications). This survey will **not** record medications that are used **as prescribed** by your doctor. However, if you have taken such medications for reasons other than prescription, or taken them more frequently or at higher doses than prescribed, please indicate this in the following questionnaire

While we are also interested in knowing about your use of various illicit drugs, please be assured that information on such use will be treated as strictly confidential.

Q1: In your life, which of the following substances have you ever used (non-medical use only)?

a) Tobacco products (cigarettes, chewing tobacco, cigars, etc.) - No/Yes
b) Alcoholic beverages (beer, wine, spirits, etc.) - No/Yes
c) Cannabis (marijuana, pot, grass, hash, etc.) - No/Yes
d) Cocaine (coke, crack, etc.) - No/Yes
e) Amphetamine-type stimulants (speed, meth, ecstasy, etc.) - No/Yes
f) Inhalants (nitrous, glue, petrol, paint thinner, etc.) - No/Yes
g) Sedatives or sleeping pills (diazepam, alprazolam, flunitrazepam, midazolam, etc.) - No/Yes
h) Hallucinogens (LSD, acid, mushrooms,t rips, ketamine, etc.) - No/Yes
i) Opioids (heroin, morphine, methadone, buprenorphine, codeine, etc.) - No/Yes
j) Other – specify: - No/Yes

Stop interview if no to all!

Q2: In the past three months, how often have you used the substances you mentioned (first drug, second drug, etc)?

a) Tobacco products (cigarettes, chewing tobacco, cigars, etc.) - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)
b) Alcoholic beverages (beer, wine, spirits, etc.) - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)
c) Cannabis (marijuana, pot, grass, hash, etc.) - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)
d) Cocaine (coke, crack, etc.) - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)
e) Amphetamine-type stimulants (speed, meth, ecstasy, etc.) - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)
f) Inhalants (nitrous, glue, petrol, paint thinner, etc.) - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)
g) Sedatives or sleeping pills (diazepam, alprazolam, flunitrazepam, midazolam, etc.) - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)
h) Hallucinogens (LSD, acid, mushrooms,t rips, ketamine, etc.) - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)
i) Opioids (heroin, morphine, methadone, buprenorphine, codeine, etc.) - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)
j) Other – specify: - Never (0), once or twice (2), monthly (3), weekly (4), daily or almost daily (6)

If "Never" to all items in Q2, skip to Q6.

Q3: During the past three months, how often have you had a strong desire or urge to use (first drug, second drug, etc)?

a) Tobacco products (cigarettes, chewing tobacco, cigars, etc.) - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)
b) Alcoholic beverages (beer, wine, spirits, etc.) - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)
c) Cannabis (marijuana, pot, grass, hash, etc.) - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)

d) Cocaine (coke, crack, etc.) - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)
e) Amphetamine-type stimulants (speed, meth, ecstasy, etc.) - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)
f) Inhalants (nitrous, glue, petrol, paint thinner, etc.) - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)
g) Sedatives or sleeping pills (diazepam, alprazolam, flunitrazepam, midazolam, etc.) - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)
h) Hallucinogens (LSD, acid, mushrooms, trips, ketamine, etc.) - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)
i) Opioids (heroin, morphine, methadone, buprenorphine, codeine, etc.) - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)
j) Other – specify: - Never (0), once or twice (3), monthly (4), weekly (5), daily or almost daily (6)

Q4: During the past three months, how often has your use of (first drug, second drug, etc) led to health, social, legal or financial problems?

a) Tobacco products (cigarettes, chewing tobacco, cigars, etc.) - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)
b) Alcoholic beverages (beer, wine, spirits, etc.) - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)
c) Cannabis (marijuana, pot, grass, hash, etc.) - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)
d) Cocaine (coke, crack, etc.) - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)
e) Amphetamine-type stimulants (speed, meth, ecstasy, etc.) - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)
f) Inhalants (nitrous, glue, petrol, paint thinner, etc.) - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)
g) Sedatives or sleeping pills (diazepam, alprazolam, flunitrazepam, midazolam, etc.) - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)
h) Hallucinogens (LSD, acid, mushrooms, trips, ketamine, etc.) - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)
i) Opioids (heroin, morphine, methadone, buprenorphine, codeine, etc.) - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)
j) Other – specify: - Never (0), once or twice (4), monthly (5), weekly (6), daily or almost daily (7)

Q5: During the past three months, how often have you failed to do what was normally expected of you because of your use of (first drug, second drug, etc)?

a) Tobacco products (cigarettes, chewing tobacco, cigars, etc.) - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)
b) Alcoholic beverages (beer, wine, spirits, etc.) - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)
c) Cannabis (marijuana, pot, grass, hash, etc.) - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)
d) Cocaine (coke, crack, etc.) - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)
e) Amphetamine-type stimulants (speed, meth, ecstasy, etc.) - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)
f) Inhalants (nitrous, glue, petrol, paint thinner, etc.) - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)

g) Sedatives or sleeping pills (diazepam, alprazolam, flunitrazepam, midazolam, etc.) - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)
h) Hallucinogens (LSD, acid, mushrooms, trips, ketamine, etc.) - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)
i) Opioids (heroin, morphine, methadone, buprenorphine, codeine, etc.) - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)
j) Other – specify: - Never (0), once or twice (5), monthly (6), weekly (7), daily or almost daily (8)

Ask questions 6 & 7 for all substances ever used (i.e. those endorsed in Q1).

Q6: Has a friend or relative or anyone else ever expressed concern about your use of (first drug, second drug, etc)?

a) Tobacco products (cigarettes, chewing tobacco, cigars, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
b) Alcoholic beverages (beer, wine, spirits, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
c) Cannabis (marijuana, pot, grass, hash, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
d) Cocaine (coke, crack, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
e) Amphetamine-type stimulants (speed, meth, ecstasy, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
f) Inhalants (nitrous, glue, petrol, paint thinner, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
g) Sedatives or sleeping pills (diazepam, alprazolam, flunitrazepam, midazolam, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
h) Hallucinogens (LSD, acid, mushrooms, trips, ketamine, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
i) Opioids (heroin, morphine, methadone, buprenorphine, codeine, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
j) Other – specify: - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)

Q7: Have you ever tried to cut down on using (first drug, second drug, etc) but failed?

a) Tobacco products (cigarettes, chewing tobacco, cigars, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
b) Alcoholic beverages (beer, wine, spirits, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
c) Cannabis (marijuana, pot, grass, hash, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
d) Cocaine (coke, crack, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
e) Amphetamine-type stimulants (speed, meth, ecstasy, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
f) Inhalants (nitrous, glue, petrol, paint thinner, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
g) Sedatives or sleeping pills (diazepam, alprazolam, flunitrazepam, midazolam, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
h) Hallucinogens (LSD, acid, mushrooms, trips, ketamine, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)

i) Opioids (heroin, morphine, methadone, buprenorphine, codeine, etc.) - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)
j) Other – specify: - No, never (0), yes, in the past 3 months (6), yes, but not in the past 3 months (3)

Q8: Have you ever used any drug by injection (non-medical use only)?

5.3. Screening question on openness/willingness to engage with clinical services

- Have you accessed a mental health service?
    - Yes, currently accessing services
    - Yes, within past 6 months
    - Yes, within the past year or two
    - Yes, a few years ag
    - No

(If no) Would you be willing to access a service in the future?

- Yes/no (If no open text field why?)

6. Sociodemographic information

- Date of birth:
- Gender: What is your gender identity
    - Male
    - Female
    - X (Indeterminate/Intersex/Unspecified)
- Sex assigned at birth: What sex were you assigned at birth, what was on your original birth certificate?
    - Male
    - Female
    - X
- Pronoun: What is your preferred pronoun?
    - He/him
    - She/her
    - They/them
    - Other, please specify:
- Country of birth: Where were you born?
    - Australia
    - New Zealand
    - Africa
    - Asia
    - Central America
    - North America
    - South America
    - Europe
    - Oceania
    - Middle East
    - If not Australia or New Zealand, please specify country:
    - If not Australia, specify age arrived in Australia:___ years
- Aboriginal or Torres Strait Islander: Are you Aboriginal or Torres Strait Islander?
    - No
    - Yes
- Language spoken at home: What language do you speak at home most of the time?
    - English
    - Other, please specify
- English: How well can you speak and understand English?

    - Native language
    - Second language
    - No English
- Current relationship status: What is your current relationship status?
    - Never married
    - In a relationship
    - Married/de facto (two people who live together as partners)
    - Separated but not divorced
    - Divorced
    - Widowed
    - Other, please specify:
- Duration of relationship: If 'in a relationship' or 'married/de facto', how long have you been with your partner?
    - N/A, not in a relationship
    - Less than 3 months
    - 3 months to 2 years
    - More than 2 years
- Sexual orientation: How would you best describe your sexual orientation?
    - Straight (attracted to a different sex)
    - Gay or Lesbian (attracted to the same sex)
    - Bisexual or pansexual (attracted to more than one sex)
    - Undecided, not sure or questioning
    - Prefer not to say
    - Other, please specify:
- Number of children: How many children do you have?
    - ____
    - Prefer not to say
- Current accommodation: What is your current living situation?
    - House/flat with family of origin
    - Rented room
    - Rented flat/house
    - Owned flat/house
    - Boarding house/
    - Homeless or couch surfing
    - Other, (specify)
- Person(s) with whom living: Who do you currently live with?
    - Alone
    - Both parents
    - Mother/step-mother/foster mother only
    - Father/step-father/foster father
    - Sibling(s)
    - Partner
    - Son(s)/daughter(s)
    - Friend(s)
    - Housemate
    - Grandparents or extended family
    - Other, (specify)
- Post code:

7. Additional measures

7.1. FTND- Fagerström Test for Nicotine Dependence

Do you currently smoke cigarettes? No/yes

If "yes," read each question below. For each question, enter the answer choice which best describes your response.

- Q1: How soon after you wake up do you smoke your first cigarette? Within 5 minutes/ 31 to 60 minutes/ 6 to 30 minutes/ after 60 minutes
- Q2: Do you find it difficult to refrain from smoking in places where it is forbidden (e.g., in church, at the library, in the cinema)? No/yes
- Q3: Which cigarette would you hate most to give up? The first one in the morning, any other
- Q4: How many cigarettes per day do you smoke? 10 or less, 21-30, 11-20, 31 or more
- Q5: Do you smoke more frequently during the first hours after waking than during the rest of the day? No/yes
- Q6: Do you smoke when you are so ill that you are in bed most of the day? No/yes

7.2. K10

In the past 4 weeks:

1. About how often did you feel tired out for no good reason? - None of the time, a little of the time, some of the time, most of the time, all of the time
2. About how often did you feel nervous? - None of the time, a little of the time, some of the time, most of the time, all of the time
3. About how often did you feel so nervous that nothing could calm you down? - None of the time, a little of the time, some of the time, most of the time, all of the time
4. About how often did you feel hopeless? - None of the time, a little of the time, some of the time, most of the time, all of the time
5. About how often did you feel restless or fidgety? - None of the time, a little of the time, some of the time, most of the time, all of the time
6. About how often did you feel so restless you could not sit still? - None of the time, a little of the time, some of the time, most of the time, all of the time
7. About how often did you feel depressed? - None of the time, a little of the time, some of the time, most of the time, all of the time
8. About how often did you feel that everything was an effort? - None of the time, a little of the time, some of the time, most of the time, all of the time
9. About how often did you feel so sad that nothing could cheer you up? - None of the time, a little of the time, some of the time, most of the time, all of the time
10. About how often did you feel worthless? - None of the time, a little of the time, some of the time, most of the time, all of the time

7.3. The Active Australia Survey

The next questions are about any physical activities that you may have done in the last week:

1. In the last week, how many times have you walked continuously, for at least 10 minutes, for recreation, exercise or to get to or from places? ___ times
2. What do you estimate was the total time that you spent walking in this way in the last week? In hours and/or minutes
3. In the last week, how many times did you do any vigorous gardening or heavy work around the yard, which made you breathe harder or puff and pant? ___ times
4. What do you estimate was the total time that you spent doing vigorous gardening or heavy work around the yard in the last week? In hours and/or minutes

The next questions exclude household chores, gardening or yardwork:

5. In the last week, how many times did you do any vigorous physical activity which made you breathe harder or puff and pant? (e.g. jogging, cycling, aerobics, competitive tennis) ___ times
6. What do you estimate was the total time that you spent doing this vigorous physical activity in the last week? In hours and/or minutes

7. In the last week, how many times did you do any other more moderate physical activities that you have not already mentioned? (e.g. gentle swimming, social tennis, golf) ___times
8. What do you estimate was the total time that you spent doing these activities in the last week? In hours and/or minutes

7.4. Strength items of National Health Survey

Some activities are designed to increase muscle strength or tone, such as lifting weights, resistance training, pull-ups, push-ups, or sit-ups.

1. Including any activities already mentioned, in the last week did you do any strength or toning activities? Yes, no
2. On how many days last week did you do any strength or toning activities? 1-7

8. Barriers and facilitators to engage in physical activity in and outside of substance use treatment

8.1. Treatment Acceptability and Preference Questionnaire (TAP)

The following is a treatment that has been developed based on previous research findings that have found physical activity to be helpful for managing mental health and substance use problems. Please read a description of what it is all about and then answer some questions about it.

Imagine your counsellor, psychologist or treating clinician suggests that you participate in some physical activity as part of a treatment to help you manage mental health and substance use problems. This physical activity would be matched to your preferences (length, included activities/exercise etc.) and could be either supervised or unsupervised at home/in the park/etc. You could also choose to do the physical activity alone or in a group.

Now that you have learned about the treatment, please rate the following and answer the questions by choosing the most appropriate response. There is no right or wrong answer.

1. How effective do you think this treatment will be in improving your mental health and reducing any substance use problems? 0 (not at all effective)- 1 (somewhat effective)- 2 (effective)- 3 (very effective)- 4 (very much effective)
2. How acceptable /logical does this treatment seem to you? 0-4
3. How suitable/appropriate does this treatment seem to be for improving your mental health and reducing any substance use problems? 0-4
4. How willing are you to comply with this treatment? 0-4

8.2. Exercise benefits/Barriers Scale (EBBS)

1. I enjoy physical activity. Strongly agree (SA)- Agree (A)- Disagree (D)- Strongly Disagree (SD)

2. Physical activity feelings of stress and tension for me. SA-SD

3. Physical activity improves my mental health. SA-SD

4. Physical activity takes too much of my time. SA-SD

5. I will prevent mental health concerns by doing physical activity. SA-SD

6. Physical activity tires me. SA-SD

7. Physical activity increases my muscle strength. SA-SD

8. Physical activity gives me a sense of personal accomplishment. SA-SD

9. Places for me to do physical activity are too far away. SA-SD

10. Physical activity makes me feel relaxed. SA-SD

11. Physical activity lets me have contact with friends and persons I enjoy. SA-SD

12. I am too embarrassed to do physical activity. SA-SD

13. Physical activity will keep me from having a low mood. SA-SD

14. It costs too much to do physical activity. SA-SD

15. Physical activity increases my level of physical fitness. SA-SD

16. Exercise facilities do not have convenient schedules for me. SA-SD

17. My muscle tone is improved with physical activity. SA-SD

18. Physical activity improves my sense of control. SA-SD

19. I am fatigued by physical activity. SA-SD

20. I have improved feelings of wellbeing from doing physical activity. SA-SD

21. My partner (or significant other) does not encourage doing physical activity. SA-SD

22. Physical activity increases my stamina. SA-SD

23. Physical activity improves my flexibility. SA-SD

24. Physical activity takes too much time from family relationships. SA-SD

25. My disposition is improved with physical activity SA-SD

26. Physical activity helps me sleep better at night. SA-SD

27. I will live longer if I do physical activity. SA-SD

28. I think people in exercise clothes look funny. SA-SD

29. Physical activity helps me decrease fatigue. SA-SD

30. Physical activity is a good way for me to meet new people. SA-SD

31. My physical endurance is improved by doing physical activity. SA-SD

32. Physical activity improves my self-concept. SA-SD

33. My family members do not encourage me to do physical activity. SA-SD

34. Doing physical activity increases my mental alertness. SA-SD

35. Physical activity allows me to carry out normal activities without becoming tired. SA-SD

36. Physical activity improves the quality of my work. SA-SD

37. Physical activity takes too much time from my family responsibilities. SA-SD

38. Physical activity is good entertainment for me. SA-SD

39. Physical activity increases my acceptance by others. SA-SD

40. Physical activity is hard work for me. SA-SD

41. Physical activity improves overall functioning for me. SA-SD

42. There are too few places for me to do physical activity (e.g, they are not nearby or not accessible). SA-SD

43. Physical activity improves the way my body looks. SA-SD

44. Doing physical activity increases my substance use. SA-SD

45. Doing physical activity decreases my substance use. SA-SD

46. I do not have enough motivation to do regular physical activity.

47. Physical activity gives me a similar feeling as substance use does.

48. I do not have the right equipment to do physical activity (e.g, exercise gear, equipment, exercise clothes)

9. Opt-in option

Are you 18 years or older and would like to participate in a subsequent focus group on barriers to physical activity participation experienced by young people?

As part of this study, we are conducting a subsequent focus group (30-60 min) that we would like to invite you to participate in. If you are interested you will be forwarded to an information page, which will inform you on the purpose, risks, and gain of the focus group.

To participate in the focus group, you will be asked to provide your contact details. These details will be collected independently from your survey participation; there will be no link between your survey participation and the focus group. This ensures that your survey participation will remain completely anonymous.

By clicking **next** I certify that I am 18 years of age or older and interested in reading more about the focus group (you will not be required to provide any contact details at this point).

Appendix B.4

Quantitative data analysis – Data preparation

R packages used for data exploration and analysis:

Package	Purpose
ggplot2	Visualisation and manipulation
tidyverse	Visualisation and manipulation
dplyr	Visualisation and manipulation
poLCA	Latent class analysis
cluster	Cluster analysis
viridis	Color maps
factoextra	Visualisation of multivariate data analyses
haven	Import and export SPSS files
mgcv	Generalised additive modelling
caret	Classification and regression analyses
rpart	Recursive partitioning and regression trees
Rpart.plot	Visualisation of regression tree analyses
gratia	Visualisation of GAMs (mgcv package)
ggeffects	Manipulation of predictive statistical models
caret	Classification and regression training
forcats	Factor manipulation
ggparty	Connection of ggplot2 and partykit package
partykit	Visualisation and fitting (inference trees)
flextable	Visualisation of tables
grid	Graphical functions
tree	Classification and regression trees

Manual error checking in online survey data:

Variables	Variable type	Minimum	Maximum	Mean	Missing (%)**
Screening: Consent check	Categorical	Within accurate range	Within accurate range	Within accurate range	0%
Screening: Age	Categorical	Within accurate range	Within accurate range	Within accurate range	0%
Screening: Substance use (WHO ASSIST)	Categorical (individual items)/ Quantitative (Sum score)	Within accurate range	Within accurate range	Within accurate range	< 10% (considering skip and display logic)
Screening: Willingness to engage with clinical service	Categorical	Within accurate range	Within accurate range	Within accurate range	< 10% (considering skip and display logic)
Sociodemographic information	Categorical	Within accurate range	Within accurate range	Within accurate range	< 10% (considering skip and display logic)

Nicotine dependence (FTND)	Categorical (individual items)/ Quantitative (sum score)	Within accurate range	Within accurate range	Within accurate range	< 10%
K10	Categorical (individual items)/ Quantitative (sum score)	Within accurate range	Within accurate range	Within accurate range	< 10%
Walking for 10 min: times/week (AAS)	Categorical	**Out of range (too low)**	Within accurate range	Within accurate range	< 10%
Heavy yard work: times/week (AAS)	Categorical	Within accurate range	Within accurate range	Within accurate range	< 10%
Vigorous PA: times/week (AAS)	Categorical	Within accurate range	Within accurate range	Within accurate range	< 10%
Moderate PA: times/week (AAS)	Categorical	Within accurate range	Within accurate range	Within accurate range	< 10%
Physical strength (National Health Survey)	Categorical	Within accurate range	Within accurate range	Within accurate range	**17.9%**
Treatment acceptability (TAP)	Categorical (individual items)/ Quantitative (sum score)	Within accurate range	Within accurate range	Within accurate range	< 10%
Exercise benefits (EBBS)	Categorical (individual items)/ Quantitative (sum score)	Within accurate range	Within accurate range	Within accurate range	13.8%
Exercise barriers (EBBS)	Categorical (individual items)/ Quantitative (sum score)	Within accurate range	Within accurate range	Within accurate range	11.7%
Age	Quantitative (Scale)	**1 case out of range (too young)**	**1 case out of range (too old)**	Within accurate range	< 10%
Total time walking: min/week (AAS)	Quantitative (Scale)	**Out of range (too low)**	**Out of range (too high)**	Within accurate range	< 10%
Total time heavy yard work: min/week (AAS)	Quantitative (Scale)	Within accurate range	Within accurate range	Within accurate range	**17.9%**
Total time vigorous PA: min/week (AAS)	Quantitative (Scale)	Within accurate range	Within accurate range	Within accurate range	13.8%
Total time moderate PA: min/week (AAS)	Quantitative (Scale)	Within accurate range	Within accurate range	Within accurate range	**24.8%**
PA times per week (times/week)	Quantitative (Scale)	**Out of range (too low)**	Out of accurate range	Within accurate range	< 10%
PA minutes per week (min/week)	Quantitative (Scale)	**Out of range (too low)**	Within accurate range	Within accurate range	< 10%
Substance use risk level	Categorical	Within accurate range	Within accurate range	Within accurate range	< 10%

* Note. Erroneous values in red
** Only user-defined missing values (system-generate missing values replaced with 0)

Kolmogorov-Smirnov and Shapiro-Wilk tests of normality:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.

Age (rounded)	.143	140	<.001	.939	140	<.001
Alcoholic beverages sum score	.119	145	<.001	.943	145	<.001
Cannabis sum score	.234	145	<.001	.744	145	<.001
Cocaine sum score	.388	145	<.001	.444	145	<.001
Amphetamines sum score	.372	145	<.001	.480	145	<.001
Inhalants sum score	.464	145	<.001	.330	145	<.001
Sedatives sum score	.418	145	<.001	.501	145	<.001
Hallucinogens sum score	.408	145	<.001	.523	145	<.001
Opioids sum score	.498	145	<.001	.287	145	<.001
Other substances Sum score	.520	145	<.001	.167	145	<.001
PA Benefits sum score	.058	125	.200*	.977	125	.032
PA Barriers sum score	.074	128	.086	.986	128	.237
Treatment acceptability sum score	.120	137	<.001	.965	137	.001
Mental health sum score	.083	143	.016	.980	143	.038
PA Minutes (total/week)	.288	132	<.001	.483	132	<.001
PA Times (total/week)	.175	117	<.001	.864	117	<.001
Nicotine dependence sum score	.482	143	<.001	.535	143	<.001
Tobacco sum score	.208	145	<.001	.785	145	<.001
Moderate PA Minutes (total/week)	.384	109	<.001	.289	109	<.001
Vigorous PA Minutes (total/week)	.224	124	<.001	.766	124	<.001
Heavy Work Minutes (total/week)	.357	118	<.001	.451	118	<.001
Walking Minutes (total/week)	.251	133	<.001	.644	133	<.001

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Appendix B.5

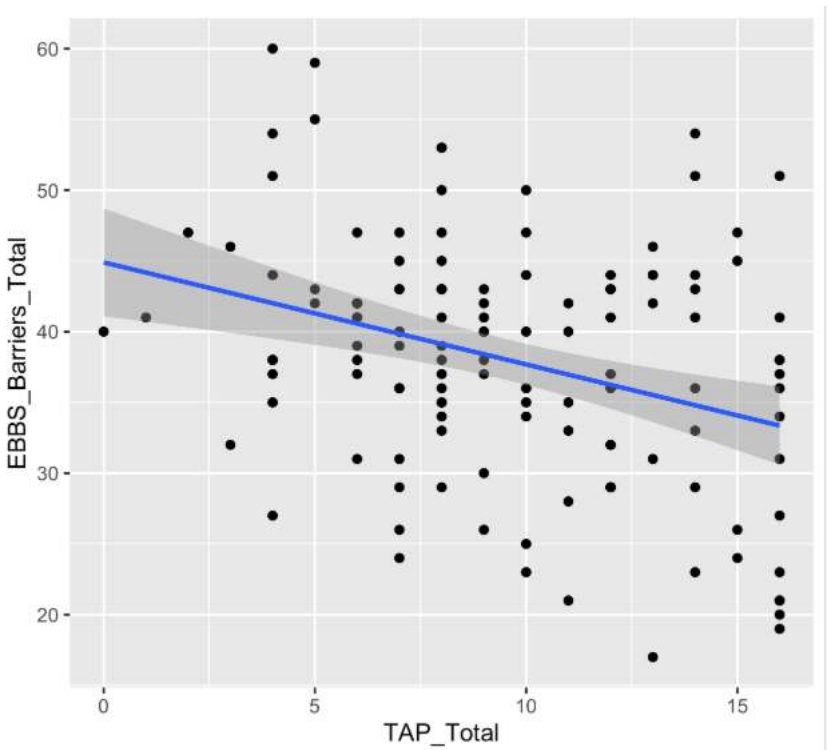
R assessment - Linear vs. nonlinear model fit

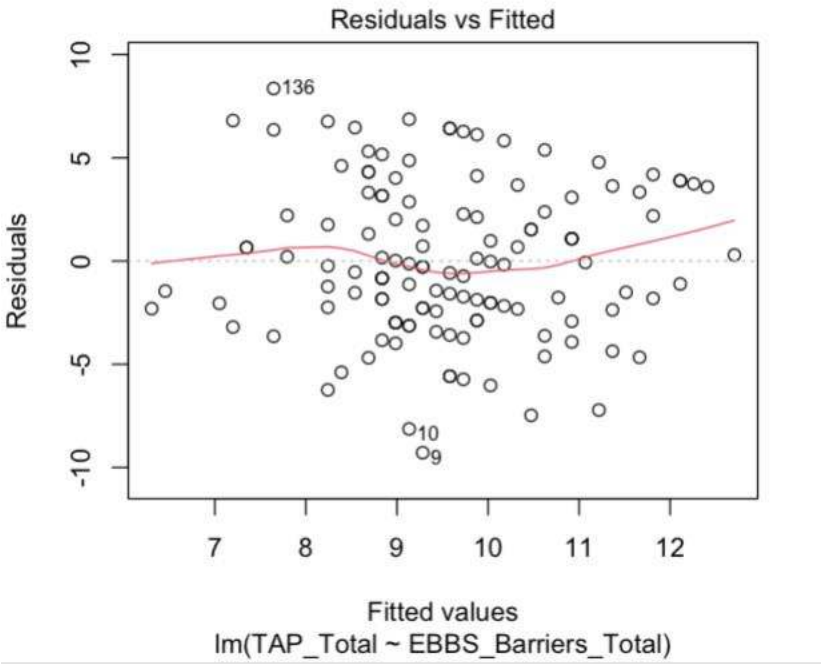
R assessment of linear model fit:

```
ggplot(TransformedData, aes(x=TAP_Total, y=EBBS_Barriers_Total))+
  geom_point()+
  geom_smooth(method=lm)

trial_model <- lm(TAP_Total ~ EBBS_Barriers_Total, data=TransformedData)

plot(trial_model, which=1)
```





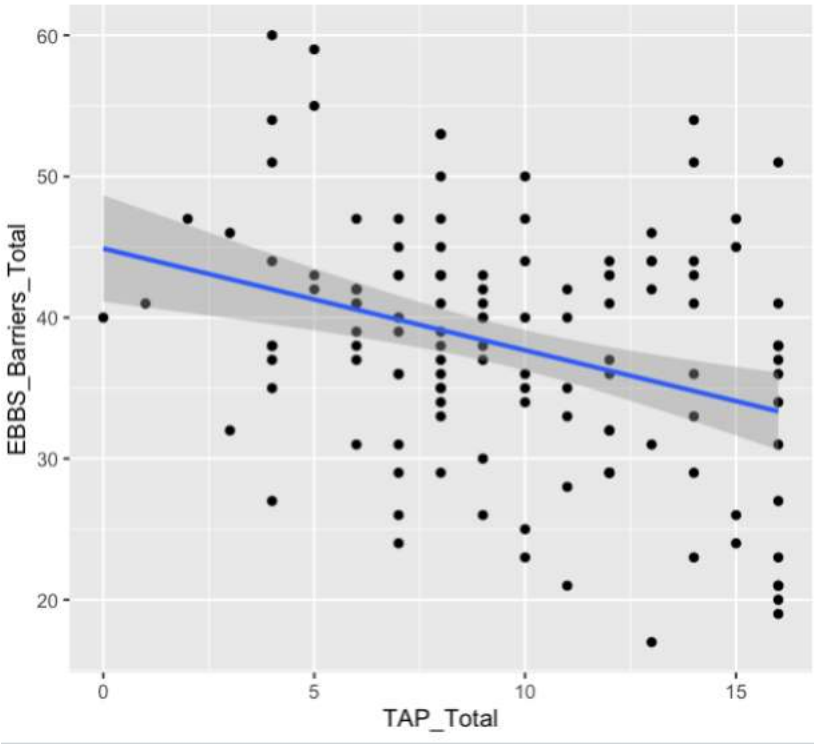
R assessment of nonlinear fit:

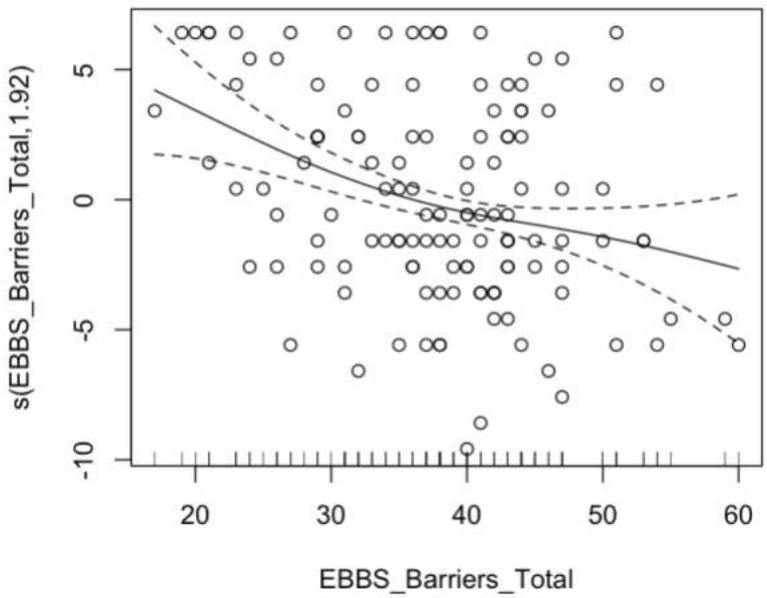
```
trial_gam <- gam(TAP_Total ~ s(EBBS_Barriers_Total),
                 data=TransformedData,
                 method="REML")

ggplot(TransformedData, aes(x=TAP_Total, y=EBBS_Barriers_Total))+
  geom_point()+
  geom_smooth(method="gam", formula = y ~ s(x))

plot(trial_gam, residuals=TRUE, pch=1)

par(mfrow = c(2, 2))
gam.check(trial_gam)
```


EBBS_Barriers_Total
60
50
40
30
20
0
5
10
15
TAP_Total


s(EBBS_Barriers_Total,1.92)
5
0
-5
-10
20
30
40
50
60
EBBS_Barriers_Total

Appendix B.6

Correlation and subgroup analyses

Significant Spearman rho correlations of treatment acceptability and perceived barriers to PA:

Correlations

					Ugly exercise clothes	Partner discouragement	Family discouragement	Hard work	PA increases SU	Too much time	Tiring	Fatigueing	Less time for relationships	Takes time from responsibilities
Spearman's rho	Treatment acceptability	Correlation Coefficient			-.224*	-.244**	-.318**	-.265**	-.319**	-.268**	-.225*	-.227*	-.218*	-.215*
		Sig. (2-tailed)			.011	.006	<.001	.003	<.001	.002	.011	.010	.014	.015
		N			127	127	127	127	127	127	127	127	127	127
		Bootstrap[c]	Bias		-.002	.000	.001	.004	.000	.005	.002	.002	.000	-.003
			Std. Error		.087	.084	.081	.090	.085	.085	.087	.090	.092	.096
			BCa 95% Confidence Interval	Lower	-.392	-.400	-.466	-.427	-.485	-.429	-.389	-.396	-.382	-.385
				Upper	-.036	-.072	-.150	-.073	-.156	-.088	-.057	-.022	-.035	-.037

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Significant Spearman rho correlations of treatment acceptability and perceived benefits to PA:

Correlations

					Improves mental health	Decreases stress/tension	Enjoyment	Prevents low mood	Prevents mental illness	Improves functioning	Relaxing	Improves behavior	Decreases tiredness	Sense of accomplishment
Spearman's rho	Treatment acceptability	Correlation Coefficient			.484**	.533**	.448**	.472**	.496**	.436**	.465**	.425**	.434**	.422**
		Sig. (2-tailed)			<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
		N			127	127	127	127	127	127	127	127	127	127
		Bootstrap[c]	Bias		-.002	-.005	-.004	-.005	-.007	-.002	-.005	-.002	-.001	-.003
			Std. Error		.069	.067	.077	.073	.079	.083	.079	.084	.076	.076
				Lower	.349	.395	.286	.314	.335	.270	.304	.243	.266	.268

		BCa 95% Confidence Interval	Upper	.602	.646	.585	.600	.624	.587	.597	.582	.569	.555

**. Correlation is significant at the 0.01 level (2-tailed).
c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Correlations

					Improves character	Improves work quality	Improves wellbeing	Decreases fatigue	Decreases SU	Enables social interaction	Increases mental alertness	Mimics SU feeling	Meet new people	Entertainment
Spearman's rho	Treatment acceptability	Correlation Coefficient			.429**	.411**	.422**	.391**	.390**	.380**	.359**	.339**	.322**	.325**
		Sig. (2-tailed)			<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
		N			126	126	126	126	126	126	126	126	126	126
		Bootstrap[c]	Bias		-.004	-.002	-.001	-.007	-.004	.000	-.004	-.005	-.006	-.003
			Std. Error		.082	.079	.079	.084	.083	.087	.087	.091	.085	.088
			BCa 95% Confidence Interval	Lower	.275	.247	.260	.236	.229	.188	.187	.160	.160	.149
				Upper	.577	.553	.573	.532	.535	.538	.512	.495	.475	.482

**. Correlation is significant at the 0.01 level (2-tailed).
c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

					Improves sleep	Improves body looks	Increases life span	Increases others' acceptance	Improves sense of control	Increases stamina	Improves endurance
Spearman's rho	Treatment acceptability	Correlation Coefficient			.313**	.281**	.275**	.250**	.251**	.195*	.198*
		Sig. (2-tailed)			<.001	.001	.002	.005	.004	.028	.025
		N			127	127	127	127	127	127	127
		Bootstrap[c]	Bias		-.001	.000	-.003	-.001	.001	.001	.000
			Std. Error		.082	.082	.085	.086	.086	.081	.082
			BCa 95% Confidence Interval	Lower	.152	.121	.109	.076	.056	.039	.040
				Upper	.464	.442	.423	.414	.416	.349	.362

Differences on physical activity, mental health, and treatment acceptability according to different substance use risk level:

Hypothesis Test Summary

Null Hypothesis	Test	Sig.[a,b]	Decision

1	The distribution of Treatment acceptability (total) is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	.500	Retain the null hypothesis.
2	The distribution of PA Barriers sum score is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	.011	Reject the null hypothesis.
3	The distribution of PA Benefits sum score is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	.164	Retain the null hypothesis.
4	The distribution of Mental health sum score is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	<.001	Reject the null hypothesis.
5	The distribution of PA Minutes (total/week) is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	.464	Retain the null hypothesis.
6	The distribution of PA Times (total/week) is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	.281	Retain the null hypothesis.
7	The distribution of Walking Minutes (total/week) is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	.190	Retain the null hypothesis.
8	The distribution of Heavy work minutes (total/week) is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	.115	Retain the null hypothesis.
9	The distribution of Vigorous PA Minutes (total/week) is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	.355	Retain the null hypothesis.
10	The distribution of Moderate PA minutes (total/week) is the same across categories of Substance use risk level	Independent-Samples Mann-Whitney U Test	.462	Retain the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Pairwise comparison of gender and mental health:

Pairwise comparisons of gender regarding mental health

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
1 Male-2 Female	-12.872	8.386	-1.535	.125	.374
1 Male-3 Other	-46.023	15.617	-2.947	.003	.010
2 Female-3 Other	-33.150	14.392	-2.303	.021	.064

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Pairwise comparison of gender and total PA Minutes per week:

Pairwise comparisons of gender regarding total PA minutes/week

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
3 Other-2 Female	1.686	11.378	.148	.882	1.000
3 Other-1 Male	23.886	12.455	1.918	.055	.165
2 Female-1 Male	22.201	7.015	3.165	.002	.005

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Pairwise comparison of gender and total walking minutes per week:

Pairwise comparisons of gender regarding total minutes of walking/week

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
2 Female-3 Other	-10.954	13.289	-.824	.410	1.000
2 Female-1 Male	23.451	8.090	2.899	.004	.011
3 Other-1 Male	12.496	14.532	.860	.390	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Pairwise comparison of gender heavy (yard) work (total/week):

Pairwise comparisons of gender regarding total minutes of heavy (yard) work/week

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
2 Female-1 Male	14.591	6.404	2.278	.023	.068
2 Female-3 Other	-18.294	10.008	-1.828	.068	.203

1 Male-3 Other	-3.703	11.036	-.336	.737	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Pairwise comparison of gender and total minutes of moderate PA/week:

Pairwise comparisons of gender regarding total minutes of moderate PA/week

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
3 Other-2 Female	17.231	10.602	1.625	.104	.312
3 Other-1 Male	30.292	11.543	2.624	.009	.026
2 Female-1 Male	13.061	6.272	2.082	.037	.112

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

Physical activity, mental health, and treatment acceptability according to different gender:

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of PA Benefits sum score is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.536	Retain the null hypothesis.
2	The distribution of PA Barriers sum score is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.067	Retain the null hypothesis.
3	The distribution of Treatment acceptability is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.106	Retain the null hypothesis.
4	The distribution of K10_MentalHealth_Total is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.012	Reject the null hypothesis.
5	The distribution of PA Minutes total/week is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.006	Reject the null hypothesis.
6	The distribution of PA Times total/week is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.069	Retain the null hypothesis.
7	The distribution of Moderate PA Minutes total/week is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.018	Reject the null hypothesis.

8	The distribution of Vigorous PA Minutes total/week is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.166	Retain the null hypothesis.
9	The distribution of Heavy Work Minutes total/week is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.024	Reject the null hypothesis.
10	The distribution of Walking Minutes total /week is the same across categories of Gender	Independent-Samples Kruskal-Wallis Test	.014	Reject the null hypothesis.

a. The significance level is .050.
b. Asymptotic significance is displayed.

Appendix B.7

R assessment - Inference/decision trees

R assessment of inference tree:

```
Model formula:
`Experienced PA Barriers` ~ `Severe mental disorder` + `Substance use risk` +
    `PA activity level`

Fitted party:
[1] root
|   [2] Severe mental disorder in No
|   |   [3] PA activity level in Insufficient PA: 40.636 (n = 11, err = 198.5)
|   |   [4] PA activity level in Sufficient PA: 32.730 (n = 37, err = 3473.3)
|   [5] Severe mental disorder in Yes: 41.511 (n = 45, err = 2411.2)

Number of inner nodes:    2
Number of terminal nodes: 3
```

Appendix B.8

R assessment – Latent class analysis

R assessment of class membership and model fit:

```
Conditional item response (column) probabilities, by outcome variable, for each
class (row)

Severe mental disorder:
           Pr(1)  Pr(2)
class 1:  0.7424 0.2576
class 2:  0.2020 0.7980

Sufficiently active:
           Pr(1)  Pr(2)
class 1:  0.2322 0.7678
class 2:  0.3289 0.6711

Perceived PA barriers:
           Pr(1)  Pr(2)
class 1:  0.9162 0.0838
class 2:  0.4116 0.5884

Treatment acceptability:
           Pr(1)  Pr(2)
class 1:  0.3882 0.6118
class 2:  0.5661 0.4339

Overall substance risk level:
           Pr(1)  Pr(2)
class 1:  0.9612 0.0388
class 2:  0.5192 0.4808

Estimated class population shares
 0.5728 0.4272

Predicted class memberships (by modal posterior prob.)
 0.6483 0.3517

=========================================================
Fit for 2 latent classes:
=========================================================
number of observations: 145
number of fully observed cases: 93
```

```
number of estimated parameters: 11
residual degrees of freedom: 20
maximum log-likelihood: -394.186

AIC(2): 810.3721
BIC(2): 843.1161
G^2(2): 15.61518 (Likelihood ratio/deviance statistic)
X^2(2): 12.16414 (Chi-square goodness of fit)
```

Appendix B.9

R assessment – Generalized additive modelling

GAM fit of treatment acceptability and experienced barriers as indicated by GAM:

```
Family: gaussian
Link function: identity

Formula:
TAP_Total ~ s(EBBS_Barriers_Total)

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   9.5827     0.3293    29.1   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                         edf Ref.df     F  p-value
s(EBBS_Barriers_Total) 1.915  2.421 6.657 0.000878 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.112   Deviance explained = 12.6%
-REML = 346.75  Scale est. = 13.77     n = 127
```

GAM fit of treatment acceptability and experienced barriers by substance risk level:

```
Family: gaussian
Link function: identity

Formula:
TAP_Total ~ s(EBBS_Barriers_Total, by = Overall_substance_severity)

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   9.5592     0.3385   28.24   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                                                                edf Ref.df     F p-
value
```

```
s(EBBS_Barriers_Total):Overall_substance_severitymoderate 1.802  2.271 6.565
0.00156 **
s(EBBS_Barriers_Total):Overall_substance_severitysevere   1.000  1.001 2.281
0.13348
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.108   Deviance explained = 12.8%
-REML = 345.84  Scale est. = 13.84     n = 127
```

GAM fit of treatment acceptability and experienced barriers as by sufficient PA:

```
Family: gaussian
Link function: identity

Formula:
TAP_Total ~ s(EBBS_Barriers_Total, by = Sufficient_active_vs_inactive_dichotom)

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   9.5706     0.4207   22.75   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:

edf Ref.df
s(EBBS_Barriers_Total):Sufficient_active_vs_inactive_dichotomnot active
1.000  1.000
s(EBBS_Barriers_Total):Sufficient_active_vs_inactive_dichotomsufficient active
1.584  1.969

F p-value
s(EBBS_Barriers_Total):Sufficient_active_vs_inactive_dichotomnot active
0.095 0.75934
s(EBBS_Barriers_Total):Sufficient_active_vs_inactive_dichotomsufficient active
6.070 0.00301 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.107   Deviance explained = 13.2%
-REML = 255.23  Scale est. = 14.855    n = 93
```

GAM fit of experienced barriers as predicted by mental health and PA participation:

```
Family: gaussian
Link function: identity

Formula:
EBBS_Barriers_Total ~ s(PATimes_Total_week) + s(K10_Total)

Parametric coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  37.9024     0.6372   59.48   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
                        edf Ref.df      F  p-value
s(PATimes_Total_week) 2.553  3.185  6.552 0.000321 ***
s(K10_Total)          1.000  1.001 34.163  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.348   Deviance explained = 36.7%
-REML = 413.44  Scale est. = 49.942    n = 123
```

APPENDIX C

Appendices from Chapter 4, Phase 2, Qualitative Focus Group

Young People's Expertise: A Mixed Methods Exploration

Appendix C.1

Participant information focus group

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate in this research project entitled: **Integration of physical activity in young people's substance use treatment provided by Australian clinical services.**

This project is being conducted by Prof Alex Parker (Chief investigator), Prof Melinda Craike (Associate Investigator), A/Prof Gill Bedi (Associate Investigator), Dr. Susan Kidd (Associate Investigator) and Lee Klamert (Student Investigator) from the Institute for Health and Sport, Victoria University.

Purpose and background
Research has shown that physical activity can be helpful in reducing substance use and improving mental health. However, even though studies have shown these benefits, physical activity isn't often included in existing treatments to manage mental health and substance use problems.

We are interested in finding out why physical activity is not currently a routine part of substance use and mental health services for young people.

What will I be asked to do?
If you agree to participate, you will be asked to share information in a focus group (approx. 60 min). The focus group will include open questions and discussion and will be moderated by an experienced researcher. You will be further asked to communicate within the group using an online whiteboard, sound and video; sharing your experiences regarding physical activity participation, preferences, and experienced barriers to physical activity.

Participation is voluntary. You can choose not to respond to any questions that you feel are uncomfortable and you can withdraw at any time. With your permission, the interview will be audio recorded. The information you provide will be confidential and all sources will be anonymous. If you decide at any time that you would no longer like to be involved in the research study, please inform any of the investigators listed below (contact details below). You can discontinue your participation at any time.

What will I gain from participating?
You will not gain anything for your immediate benefit as this research is still in its early stages. However, by participating in the focus group, you will contribute to understanding barriers to physical activity participation experienced by young people wanting to improve their mental health and substance use. Your participation will contribute to the investigation of facilitators aiding the integration of physical activity into existing services and explore the acceptability and usefulness of this approach. In acknowledgement of your time and effort, you will receive a $30 non-cash gift voucher.

What are the potential risks of participating in this study?
No questions on substance use or mental health will be asked during the focus. The focus group explores your experienced barriers and facilitators to physical activity participation and your preferences behaviour change. Although possible, it is unlikely that responding to these items will cause you distress. If an unexpected adverse event were to happen during the focus group, the experienced moderator will assess the situation and provide immediate debriefing if necessary and then forward your details to an external, on-call mental health clinician.

How will the information I give be used?
The de-identified information will be used for research purposes in scientific and public health related publications, research reports and conference presentations. In these publications all data will be

summarised and aims to provide guidance on how physical activity can be used in youth mental health and substance use services.

If you are willing to participate you will be asked to sign a consent form prior to the focus group. You will also have an opportunity to discuss your participation with members of the research team prior to signing the consent form.

The information you provide will be confidential, non-identifiable (alphanumerically coded) and securely stored. No individuals outside of the research team will have access to any information.

How will this study be conducted?
You will be asked to participate in a single online focus group of approximately 60 min length. The focus group will be moderated and led by a member of the research team. You will be guided through several questions on barriers to physical activity participation and acceptability and usefulness of integrating physical activity into existing services for young people aiming to improve their substance use and wellbeing. You will be introduced to a digital whiteboard software (miro.com) and use creative methods such as brainstorming and journey mapping to communicate and visualize your preferences, needs and experiences. You will be able to see and hear other participants. You will be invited to be equal research partners and asked to contribute as much as you feel comfortable with. The focus group will be held in a campfire format; one moderator will introduce the question that will be discussed in a shared environment including all participants.

The focus group will be audio-recorded and then transcribed. Only the researchers will have access to the focus group transcripts and digital whiteboard information. The analysis will be performed to identify and report themes from the focus group data, which will be used to develop recommendations for the development of strategies to integrate physical activity into youth substance use and mental health treatment.

Who is conducting the study?
The Institute for Health and Sport (iHeS), Victoria University

Any queries about your participation in this project may be directed to the Chief Investigator.

Chief Investigator:
Professor Alex Parker
Institute for Health and Sport (iHeS), Victoria University
Phone: +61 3 9919 5874 or 0466 027 803
Email: Alex.Parker@vu.edu.au

Other investigators:
Prof Melinda Craike (Victoria University), A/Prof Gill Bedi (Orygen Youth Mental Health), Dr Susan Kidd (NSW Health), Lisa (Lee) Klamert (PhD candidate, Victoria University).

If you require support as a consequence of your participation in the study, you will be able to access psychological services through the following resources:

- Lifeline Australia: 13 11 14
- Beyond Blue: 1300 22 4636
- Counselling Online: 1800 888 236
- Headspace: 1800 650 890
- Kids Helpline: 1800 55 1800
- National Alcohol and Other Drug Hotline: 1800 250 015
- DirectLine: 1800 888 236

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

Appendix C.2

Informed consent focus group

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

We would like you to be part of the research project called "**Integration of physical activity in young people's substance use and mental health treatment provided by Australian clinical services"** conducted by Prof. Alex Parker (Chief Investigator), Prof Melinda Craike (Associate Investigator), A/Prof Gill Bedi (Associate Investigator), Dr. Susan Kidd (Associate Investigator) and Lee Klamert (Student Investigator) from the Institute for Health and Sport, Victoria University.

You are invited to participate in a focus group on integrating physical activity into existing health services for young people with substance use and mental health concerns. The focus group will be conducted in the format of an inclusive, respectful, collaborative dialogue ("Campfire method").

There is a low risk of psychological distress associated with any potentially sensitive topics asked about as part of the focus group.

CERTIFICATION BY PARTICIPANT

I certify that I am at least 18 years old* and that I freely agree to participate in the focus group and collaborative dialogue exploring:

- Substance use and physical activity behaviour
- Mental health
- Preferences regarding the integration of physical activity into health services
- Barriers to physical activity participation

I understand that the focus group is being voice recorded and subsequently transcribed. The resulting written data will be stored on a secure university research server.

I have read and I understand the Participant Information and I will receive a copy of the Participant Information and Consent Form to keep.

I certify that I have had the opportunity to have any questions answered and that I understand my participation is voluntary and I can withdraw my consent to participate at any point up until the data has been analysed. At this time, the data will be merged with others, and it will not be possible to withdraw my data.

I certify that the objectives of the study and focus group, together with any risks and safeguards associated with the procedures to be carried out in the research, have been fully explained to me.

I have been informed that the information I provide will be kept confidential.
The researcher has agreed not to reveal my identity and personal details if information about this project is published or presented in any public form.

Participant's name……..……

Digital signature: **Date:**

Queries and complaints:
Any queries about your participation in this project may be directed to the Chief Investigator Professor Alex Parker. Phone: +61 3 9919 5874 or 0466 027 803 (during business hours). Email: Alex.Parker@vu.edu.au

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

Appendix C.3

Focus group schedule

DETAILED SCHEDULE ASYNCHRONOUS FOCUS GROUP

1. Introduction round

- Welcome
- Introduction (around the circle)
- "Check-in" exercise: Used for YP to become familiar with each other and facilitator in

Our topic is…

The results will be used for…

You were selected because…

2. Study information and informed consent

- Open questions
- Informed consent
- Unclarities to be discussed?

3. Introduction of approach and methods

- Overview of topic

We will be talking about how physical activity can be integrated into existing health services for young people, for example a structured physical activity program that is offered by a health service or a comprehensive health service that also has a physical activity focus. We will also talk about what needs to be done for young people to want to attend such a program or engage with such a service. If such program were to exist, how would it need to look like so you would like to attend it. What would the health service need to do or change to help young people (you?) attend such a program. What would need to happen within a health service and what would a health service need to offer that you would give such a program a chance? These are some of the questions that we will talk about together today.

- Overview of the entire session program
- Introduction of brainstorming method
- Introduction of campfire approach and miro: predefined questions presented by one moderator, fluent and flexible discussions

Think back of when you were sitting around a fire, if you haven't done this in the past, just picture it in your imagination. The fire is warm and cosy, everyone is friendly and laid back, you are looking around and see friendly faces. Someone might start a song throughout the evening or maybe it is just hours of laughing and chatting with mates. This is the environment we will try to create today. A warm and laid-back environment where everyone's opinions and views are welcome. A comfortable environment where no one is afraid to speak.

- Ground rules

No right or wrong answers, only differing points of view.

We're recording, one person speaking at a time.

We're on a first name basis.

You don't need to agree with others, but you must listen respectfully as others share their views.

Rules for cellular phones and pagers if applicable. For example: We ask that your turn off your phones. If you cannot and if you must respond to a call, please do so as quietly as possible and rejoin us as quickly as you can.

My role as moderator will be to guide the discussion.

Talk to each other.

Important: Substance use is not the topic of today's focus group, and we will try to not use any words related to substance use. The topic of today's focus group is barriers and facilitators that you are experiencing when considering participating in a PA intervention with a clinical service and preferences that you have regarding those interventions. Nevertheless, if it happens that a triggering word is being said, please let me know. We will then decide if you either turn off your camera/sound and retrieve until ready to come back, or if we will go to a breakout room and have a chat. Another option would be to send me a private message and let me know that you would like to go to a breakout room or retrieve, please all check if you have the option to send a private message.

4. Establish shared general picture of service (Miro frame "Journey Map")

- Combination of YP with different experience with health services
- Inquire who has accessed clinical service before
- Establish agreement of what a service could look like between people who have accessed service and people who haven't, so that everyone is talking about the same kind of service (i.e. First point of contact, schedule intake session, first session, explore intervention and treatment options, engage in intervention/treatment)
- Establish a shared imaginary picture of a service that we talk about, and the different steps involved

Who in this group has approached a health service before? Think of the first approaching step and the first interactions with the service, can you describe this for everyone who has not gone through this experience yet? To everyone else: Please imagine how it would be like and feel like to approach such a health service. Imagine you are going through these described steps.

5. Explore options of PA intervention within service

- How could an (ideal) physical activity treatment/program offered by a health service look like for you to want to participate in it? (Miro frame "Ideal Physical Activity Program")
  - ➔ Supervised/planned unsupervised, standardized/tailored, provided by treating clinician/provided by exercise physiologist, individual/group, in-person/online, structural intervention/behavior change intervention (do they want to achieve changes in their environment or specifically target their behavior?) (Foster et al., 2005; Marcus et al., 2006)

6. **Barriers experienced by YP(Brainstorming round 1 & 2)**
   - Presentation of most frequently named experienced barriers regarding PA participation
     1. Tiring and hard work.
     2. Not enough motivation
     3. Too costly to do regular PA

These are the most common barriers that are experienced by YP when it comes to PA.

   - ➔ Question: Do you think that substance use could be an additional barrier to PA?
   - ➔ Question: Do you think that substance use could be an influence on already existing barriers?
   - Brainstorming 1 (Miro frame "Experienced barriers"): What other barriers are you experiencing regarding all the options that have been named before?
   - Brainstorming 2 (Miro frame "Overcome barriers"): What would you like to see the health service do or provide to overcome these barriers, what would help you? (pick only top barriers that a service can reasonably address)
     How would it/the service/treatment offer feel to you if these barriers are overcome (would it make it more likely for you to engage in the treatment offer)?

7. **Facilitating factors/enablers/benefits experienced by YP (Brainstorming round 3 & 4)**
   - Presentation of most frequently named experienced enablers/benefits regarding PA participation
     1. PA increases my level of physical fitness (muscle tone, strength, stamina, endurance, flexibility)
     2. PA improves the way my body looks. -> better self-esteem? (Liu, Wu, & Ming, 2015)
     3. PA gives me a sense of personal accomplishment.
     4. PA improves my mental health and wellbeing

   - Brainstorming 3 (Miro frame "Experienced facilitators"): What other facilitators are you experiencing regarding all the options that have been named before?
   - Brainstorming 4 (Miro frame "Integrate Facilitators"): How can a service integrate these factors/enable them or use them better if they already exist? How does a PA intervention feel to you if these factors are specifically accommodated/focused on within service provision (would it make it more likely for you to engage in the treatment offer)?

8. **Repetition and drawing together**
   - Briefly repeat outcomes from brainstorming 1 and brainstorming 2
   - Create basis for investigation how a service would be able to allow choice and how it would look like

9. **Outcome: Paint an imaginary service picture (Brainstorming round 5 & 6)**
   - Exploration how service can provide choice
   - Agree that individual preferences are key
   - Brainstorming 5 (Miro frame "Integrate Choice"): How would the service allow for all of these choices; how would it look like and feel like if this were to happen? At what point could the service integrate these choices?
   - (How would it make you feel like about the treatment offer? What information would you need to help you decide what options to try?)
   - Brainstorming 6 (Miro frame "Service Team"): How could this information be shared amongst the service team – who would they like to know about their PA plan? Would it be useful for

anyone involved in their treatment to know and check in on their progress? Or would they prefer that only the person working closely with them (irrespective of discipline) is the only one discussing PA? Would they like a peer support worker to be involved or someone with lived experience?

When you look at all this information that we have collected we can certainly agree that there are many different preferences of how an ideal physical activity program or intervention could look like. We will now do one last brainstorming session on the question "How could a service allow for choice? How does a service need to look like to allow for choice? What does a service need to do to allow choice?" For example, this could be simply something such as asking for a YP's preferences regarding a PA intervention during the intake assessment. Or including a fitness assessment with an exercise physiologist as part of an intake appointment.

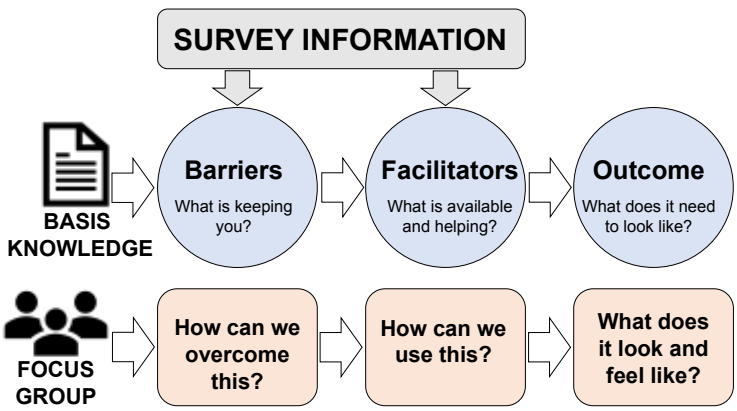
Conclusion

- Summarize everything discussed
- Confirm that YP agree with summary

Is this an adequate summary?
Of all the things we discussed and the information we collected today, what do you think is the most important?

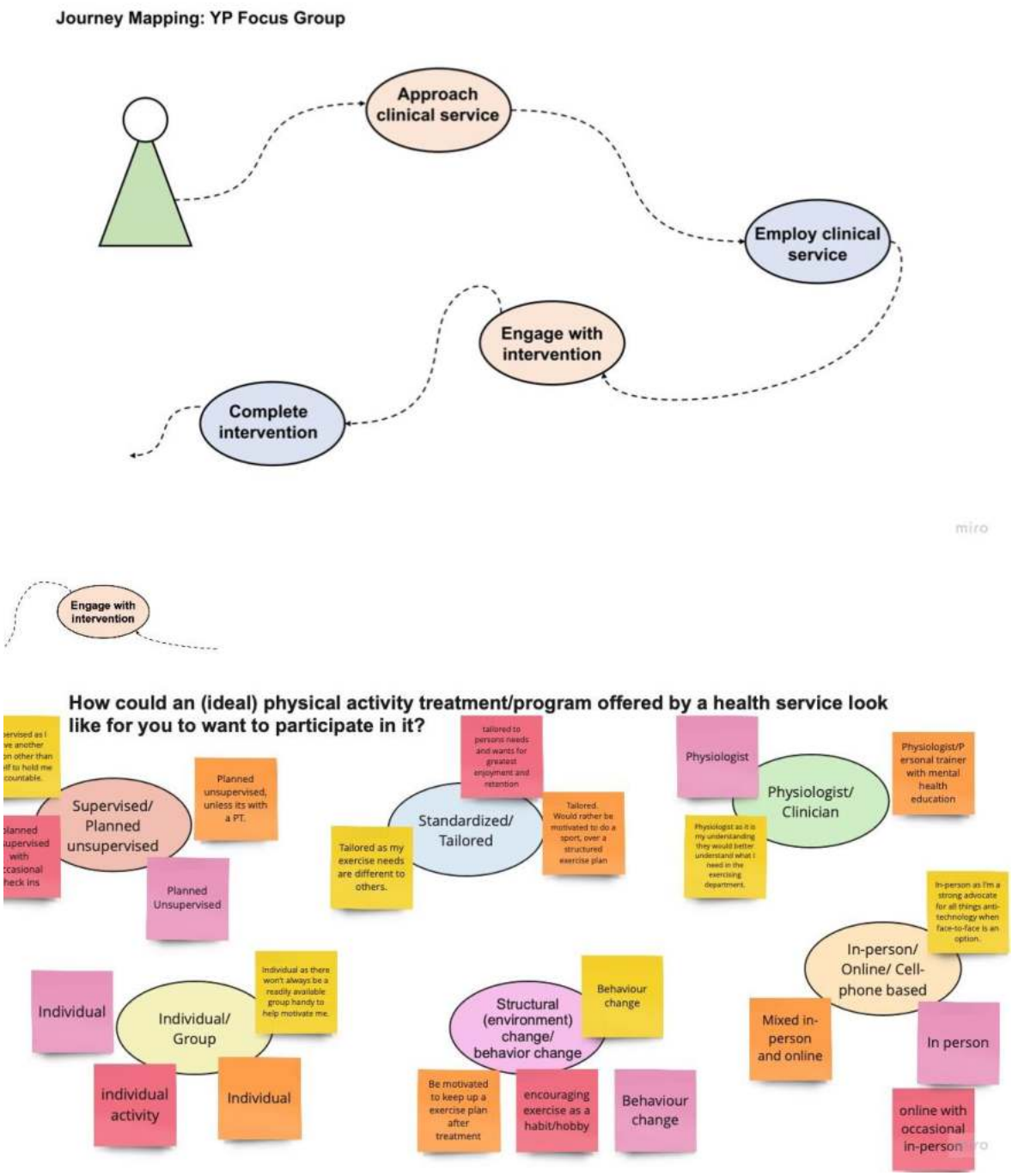
- Review purpose and ask if anything has been missed
- Inform on way of payment
- Thanks and dismissal

Focus group model:

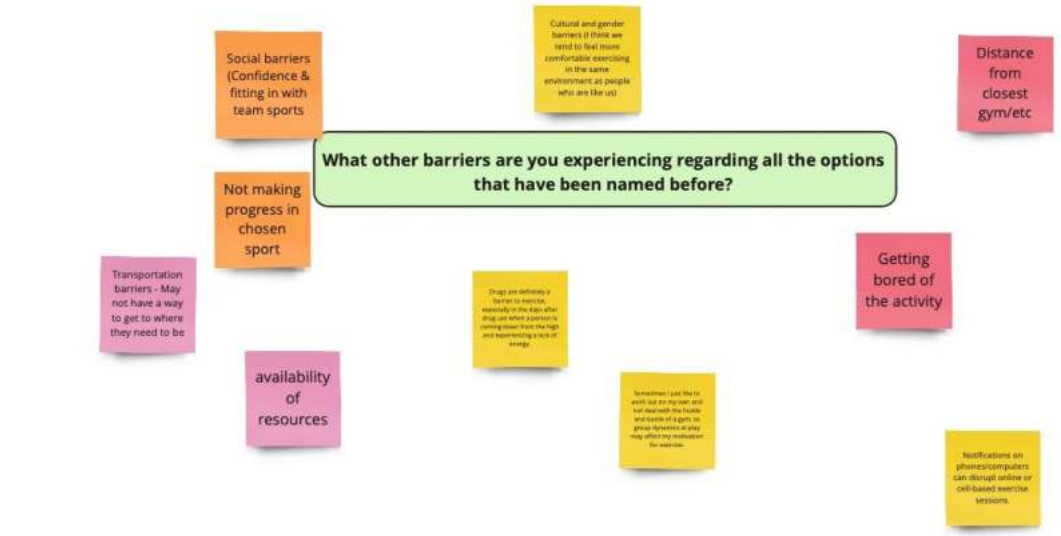


Appendix C.4

Miro brainstorming output

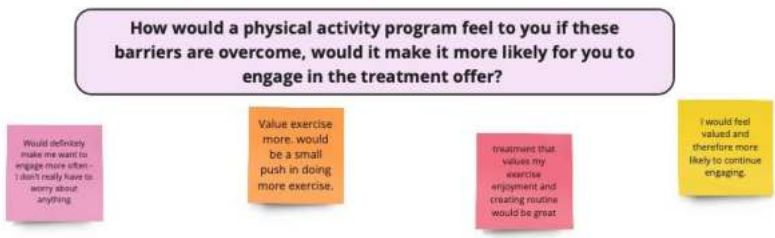


Most frequent barriers:
1. Physical activity is tiring and hard work.
2. Not enough motivation.
3. Too costly to do frequent physical activity



miro

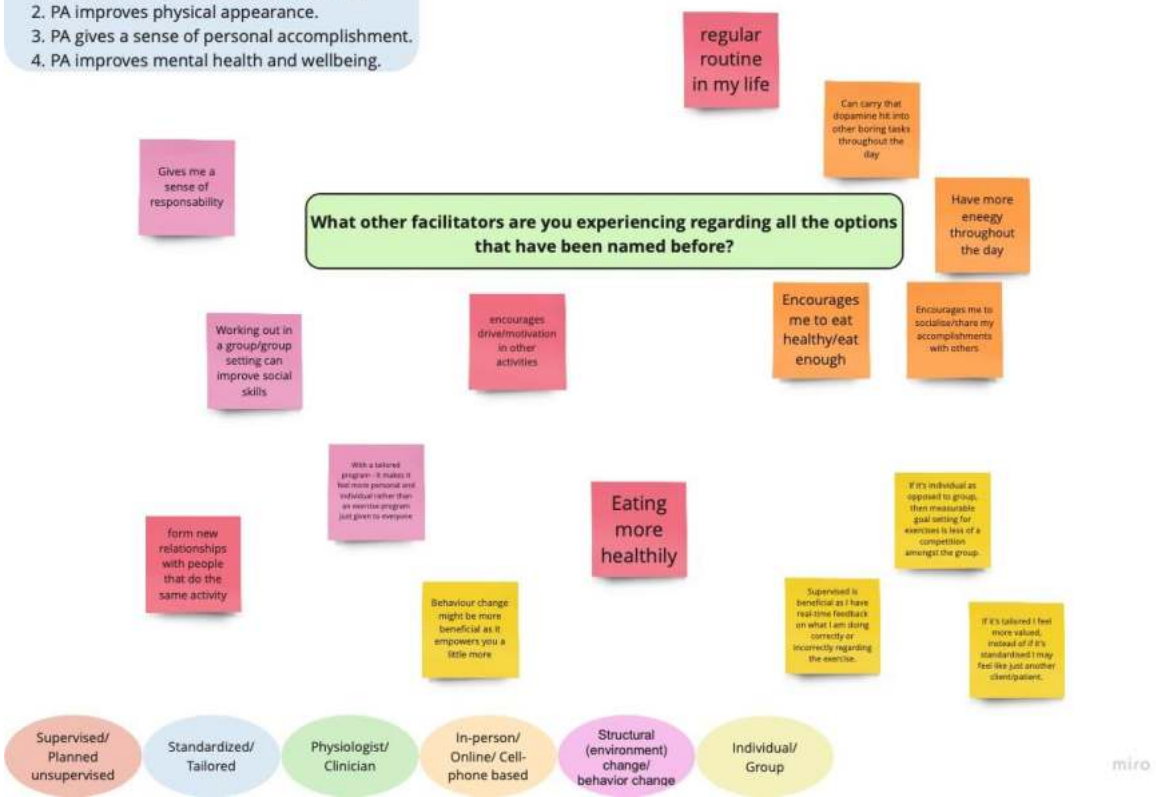
Most frequent barriers:
1. Physical activity is tiring and hard work.
2. Not enough motivation.
3. Too costly to do frequent physical activity

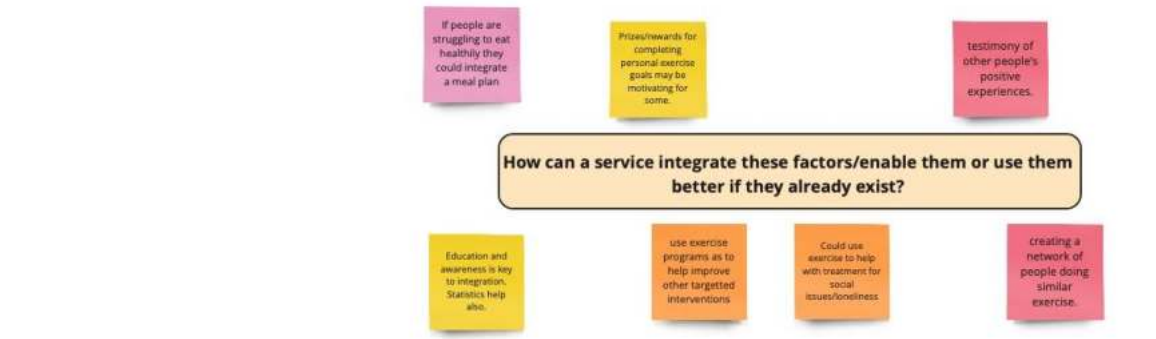


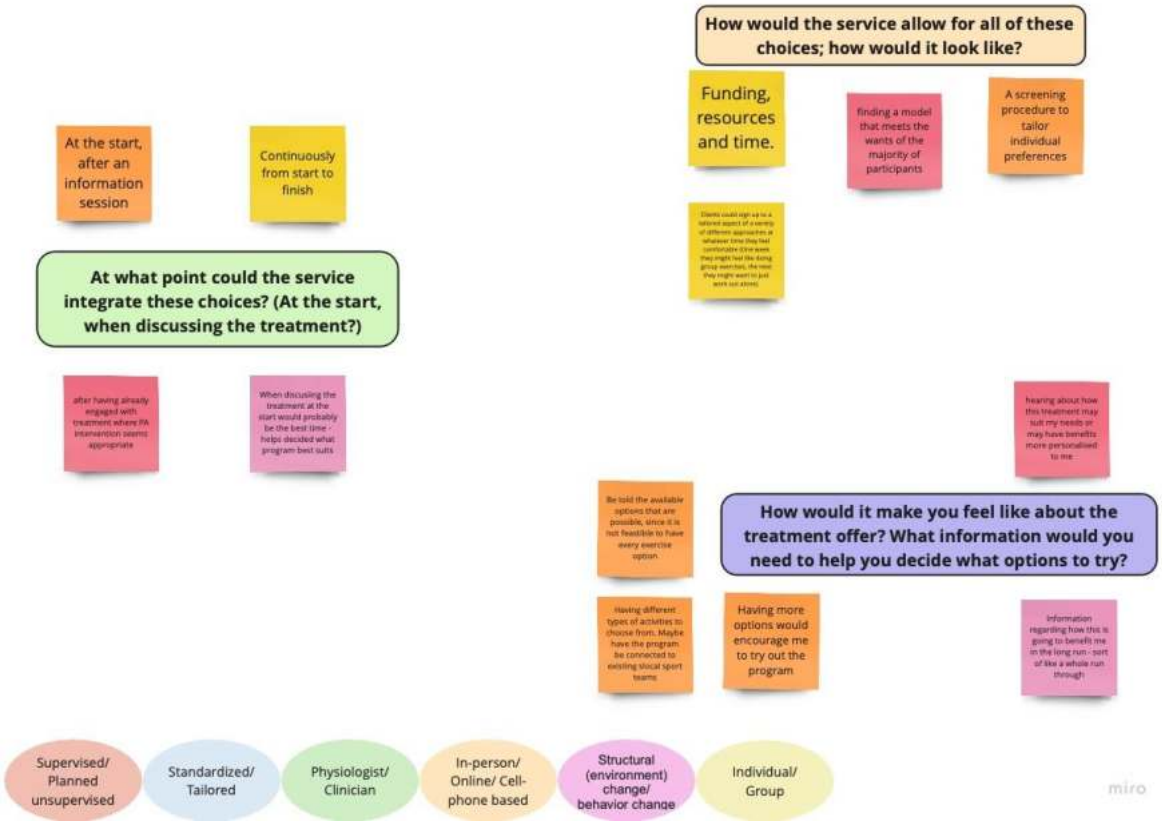
miro

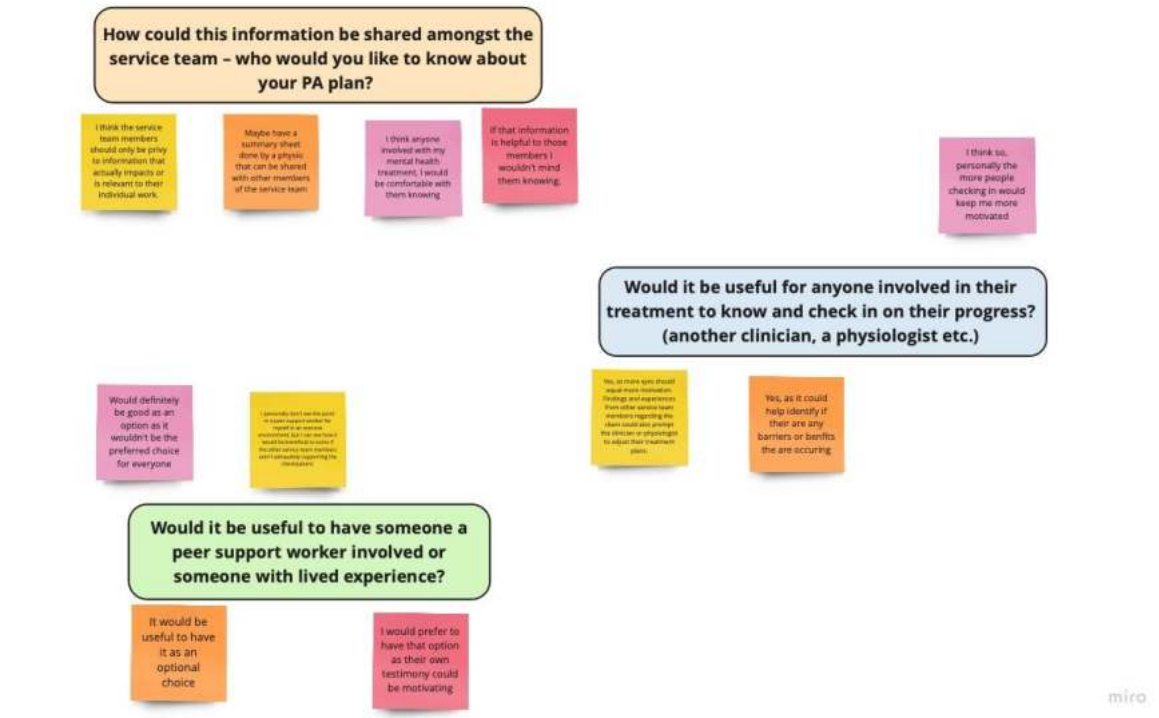
Most frequent facilitators:

1. PA increases physical fitness (muscle tone, strength, stamina, endurance, flexibility)
2. PA improves physical appearance.
3. PA gives a sense of personal accomplishment.
4. PA improves mental health and wellbeing.



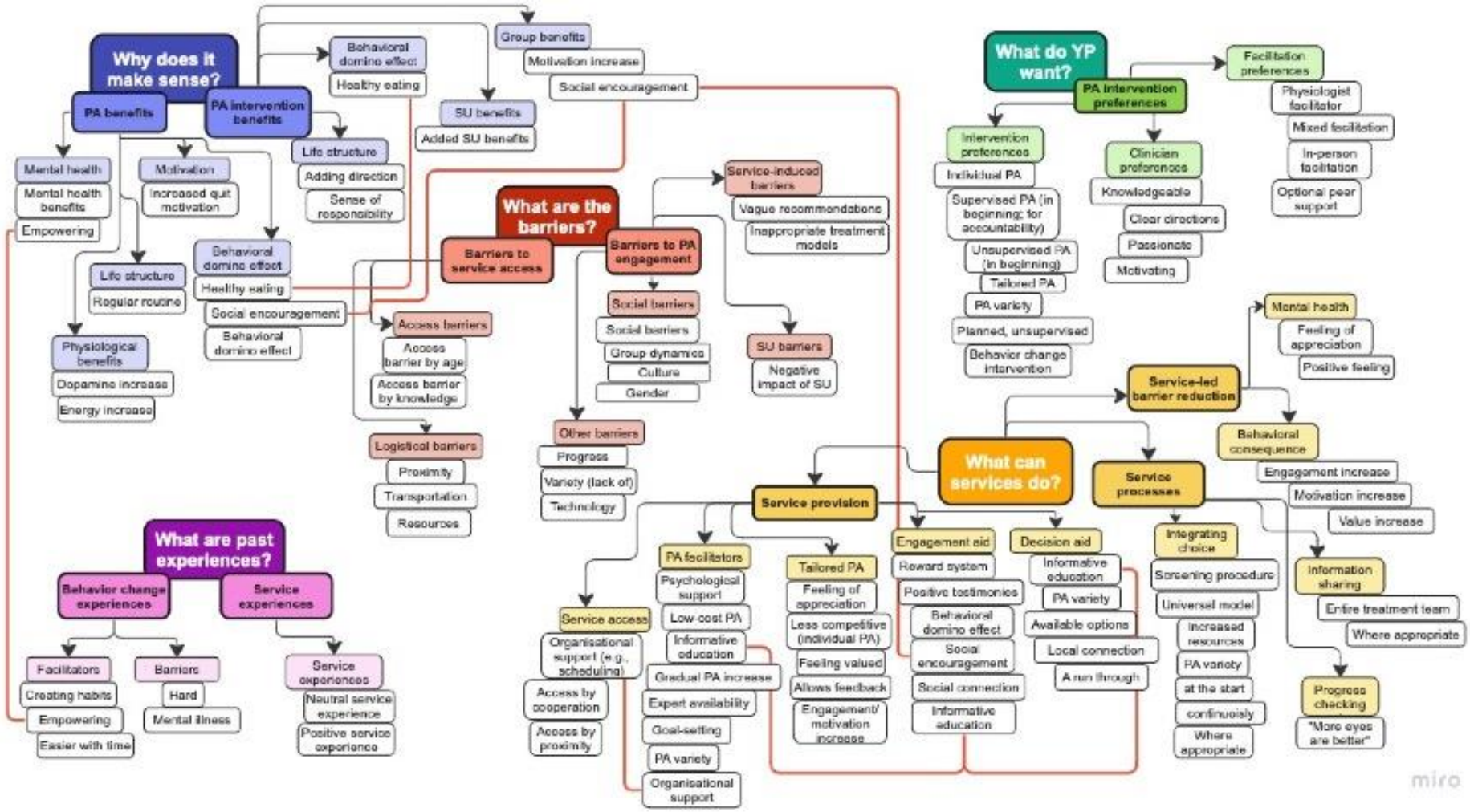



How would the service allow for all of these choices; how would it look like?
Funding, resources and time.
finding a model that meets the wants of the majority of participants
A screening procedure to tailor individual preferences
At the start, after an information session
Continuously from start to finish
At what point could the service integrate these choices? (At the start, when discussing the treatment?)
after having already engaged with treatment where PA intervention seems appropriate
When discussing the treatment at the start would probably be the best time - helps decided what program best suits
hearing about how this treatment may suit my needs or may have benefits more personalised to me
Be told the available options that are possible, since it is not feasible to have every exercise option.
How would it make you feel like about the treatment offer? What information would you need to help you decide what options to try?
Having different types of activities to choose from. Maybe have the program be connected to existing shocal sport teams
Having more options would encourage me to try out the program
Information regarding how this is going to benefit me in the long run - sort of like a whole run through
Supervised/ Planned unsupervised
Standardized/ Tailored
Physiologist/ Clinician
In-person/ Online/ Cell-phone based
Structural (environment) change/ behavior change
Individual/ Group
miro


How could this information be shared amongst the service team – who would you like to know about your PA plan?
I think the service team members should only be privy to information that actually impacts or is relevant to their individual work.
Maybe have a summary sheet done by a physio that can be shared with other members of the service team
I think anyone involved with my mental health treatment, I would be comfortable with them knowing
If that information is helpful to those members I wouldn't mind them knowing.
I think so, personally the more people checking in would keep me more motivated
Would it be useful for anyone involved in their treatment to know and check in on their progress? (another clinician, a physiologist etc.)
Yes, as it could help identify if their are any barriers or benfits the are occuring
Would definitely be good as an option as it wouldn't be the preferred choice for everyone
Would it be useful to have someone a peer support worker involved or someone with lived experience?
It would be useful to have it as an optional choice
I would prefer to have that option as their own testimony could be motivating
miro

Appendix C.5

Miro outcomes map



Appendix C.6

Qualitative content analysis – Code book

Name of Code	Code Description	Examples of Code	No. of references
Mental health benefits	Improvement of any factors associated with mental health	Reductions of depressive symptoms, increased feeling of mental wellbeing	1
Introduction	Introductory information shared by YP that is not immediately relevant to the content analysis	"*I am a student*"	4
Service experience	A YP's neutral/ positive/ negative past or present experience of a health service	"*I have had good experiences with headspace*"	3
Access barrier by age	Difficulty accessing clinical services due to age	Mental health access as adult is harder.	1
Access barrier by knowledge	Difficulty accessing clinical service due to a YP's knowledge	Extensive psychology knowledge may complicate choosing the right psychologist.	1
Access by cooperation	Access to health services dues to service-community cooperation	A health service has a cooperation with a local school	1
Access by proximity	Access to health services due to their location within a YP's immediate proximity	Location of a health service is a few door's down	1
Inappropriate treatment model	Treatment models offered by services that do not comply with client's needs	Applying unsupervised interventions at at the wrong time may reduce motivation/engagement; supervised interventions at the wrong time may be too intense	3
Creating habits	Creating habits helps to engage in regular behavioral routines	"*Once you create habits, you find yourself, doing exercise because you are used to doing it*."	1
Supervised PA (in beginning; for accountability)	Physical activity that is being facilitated by a clinician, peer, coach, exercise physiologist, or similar	Personal training session, coached soccer practice	2
Unsupervised PA	Physical activity that is not facilitated by a clinician, peer, coach or similar	Going for a run alone	1
Negative impact of SU	Negative impact of substance use on different life areas	Substance use reduces motivation and energy to exercise	11
Increased quit motivation	Increased motivation to quit substance use	Reduced physical wellbeing due to substance use increases quit motivation	1
Knowledgeable clinician	A clinician with extensive knowledgeable on physical activity	Exercise physiologist, clinician with PA training	1
Vague recommendations	Recommendations for PA that give no clear directions	"*Have like a couple of hours each week to maintain a good physical wellbeing", but they don't really go into more detail about that."*	1
Clear directions	Clear directives which physical activity, what amount, what intensity to participate in	X exercise for a duration of X minutes, X times per week (specified weekdays)	3
Passionate clinician	A clinician who is passionate about physical activity	A clinician who enjoys engagement in PA themselves	2

Name of Code	Code Description	Examples of Code	No. of references
Tailored PA	Physical activity that is tailored to a YP's needs and preferences	PA according to a YP's fitness level, preferred exercises and enjoyment	6
Hard	Something is hard to achieve	Participation in physical activity is hard in the beginning	4
Empowering	An increased feeling of empowerment induced by physical activity	---	3
Easier with time	Something is hard at first, but gets easier with time	Physical activity gets easier the more a YP participates in it	3
Added SU benefits	PA may reduce substance use and increase other health behaviour	PA induced reduction of smoking frequency	4
Psychological support/integrated PA	Psychological support provided by a health service; PA is integrated with psychological support	---	3
Adding direction	Providing a YP with direction in life (social, school life etc.)	Formulating clear goals, clear exercises, achievable tasks	1
Mental illness	Mental health struggles of a YP	E.g., depression, anxiety, suicidality	1
Motivating clinician	A clinician aiming to increase the PA motivation of a YP	Using motivating language, examples, other startegies aiming to increase a YP's motivation to engage	1
Planned, unsupervised PA	Timely planned exercise, that is not directly supervised or facilitated by a clinician	A YP follows a strict PA program such as going for runs for a set period on set days/week and reports back to clinician at scheduled check-in times	3
Physiologist facilitator	Physical activity that is facilitated by an exercise expert rather than any clinician	Eg., Personal training sessions	4
Individual PA	Physical activity that is performed individually rather than in a group	Eg., Running, swimming, triathlon	7
In-person facilitation	Physical activity that is facilitated only in-person	Weekly, in-person training sessions	2
Mixed facilitation	Physical activity that is facilitated both online (digital) and in-person	Weekly in-person group trainings paired with online one-on-one training sessions	2
Behavior change intervention	An intervention that focusses on changing a person's behaviour rather than a person's environment (structural intervention)	An intervention uses a reward system to systematically increase the frequency of PA behaviour	5
Cultural barriers	Barriers to physical activity participation due to culture	E.g., women not being allowed to participate in "traditionally male" sports	1
Gender barriers	Barriers to physical activity participation due to gender	E.g., women nor being allowed to participate in all-male team sports or vice versa	1
Social barriers	Barriers to physical activity participation due to social reasons	Social anxiety, lacking social skills	1
Proximity barrier	A barrier to physical activity participation due to distance	Living too far away	1
Progress barrier	A barrier to physical activity participation due to progress	Lack of progress	1

Name of Code	Code Description	Examples of Code	No. of references
Variety barrier	A barrier to physical activity participation due to lack of variety	Not many suitable options available	1
Transportation barrier	A barrier to physical activity participation due to transportation	Living in remote areas without access to an adequate transportation network such as regular busses	1
Resources barrier	A barrier to physical activity participation due to resources	Not enough money to buy PA clothes or PA equipment, sports club membership	1
Group dynamics barrier	A barrier to physical activity participation due to group dynamics	Negative group dynamics, highly competitive group	1
Technological barrier	A barrier to physical activity participation due to technology	Needing to be available for potential work-calls 24-7, interruptions caused by a ringing phone	1
Low-cost PA	Physical activity that does not come at large financial cost	Physical activity that is offered for free, low-cost, student rebates	1
Gradual PA increase	A gradual increase of PA from session to session	Slowly increasing the intensity, duration, or frequency of physical activity over a longer period of time	1
Expert availability	Availability of an exercise expert within a health service	A physical exercise physiologist employed on site by the health service	1
Goal-setting	Measurable goal-setting as motivator for PA progress	Applying SMART goals (Specific, Measurable, Achievable, Relevant, and Time-Bound)	1
Organisational support	Support in organisation, PA scheduling, building a PA routine etc. provided by the health service	Help with scheduling PA sessions, text reminders for sessions, scheduling compatible with school/work/university commitments	2
Feeling of appreciation	Feeling that one is important to others	Feeling valued, feeling cared for	2
Value increase	Perceiving physical activity as having more value to oneself than before	---	1
Engagement/motivation increase	A motivation or engagement increase in a YP	---	3
Positive feeling	Experiencing a positive feeling/ emotion	Feeling happy	2
Regular routine	A daily pattern/practice a YP follows	Participating in PA every morning before breakfast	2
Dopamine increase	An increase of dopamine triggered by physical activity participation	---	1
Sense of responsibility	Obtaining an increased sense of responsibility induced by PA participation	---	1
Energy increase	An increase in energy caused by PA participation	---	1
Healthy eating	Increased healthy eating as a consequence of PA participation	Eating low sugar, low fat foods, increased vegetable consumption	4
Social encouragement	Improved social skills/ increased social behavior cause by a physical activity intervention	---	5

Name of Code	Code Description	Examples of Code	No. of references
Behavioral domino effect	Participating in one behavior encourages/leads to other behavior	Participating in group PA increases social competency	3
Less competitive	Individual PA reduces potential negative competition that might take place in group-based interventions otherwise	---	1
Allows feedback	Real time feedback on exercise performance	Comments on what YP is doing correctly/ incorrectly regarding the exercise	1
Reward system	A system of receiving rewards (monetary, other) for completing goals, challenges, tasks, intervention steps	Receiving a token for each successfully completed part of an intervention	1
Positive testimonies	Other people's positive experiences, stories and opinions about a PA intervention participated in	---	2
Social connection	Building connection between YP	Connecting YP with similar exercise interests	2
Increased resources	Availability of more resources than currently available	Increased financial resources to improve PA options that are available	1
Screening procedure	A screening test aiming to uncover any physical and mental health needs and preferences of a YP	Intake assessment that includes psychological and physical assessment (fitness etc.)	1
Universal model	A model which can be applied to a range of YP with different needs and presentations	Fitness-centre model: Offering a range of different options under one roof to suit everyone	1
PA variety	Availability of different options a YP can choose from	---	1
Continuously	Providing information from the start to the end of an intervention	Discussing PA options at several times during service provision	1
Where appropriate	Providing information where relevant or appropriate within treatment	Discussing PA options whenever appropriate	1
At the start	Providing information at the intake appointment of a health service	Discussing PA options at the very start of service provision	2
Informative education	Psychoeducation, statistics and information on intervention-related content relevant to a YP	Effect of PA on dopamine distribution in the brain	1
Available options	Options that are available to choose from	A list of suitable and available PA options to discuss	5
Local connection	A connection to local sports teams	Participating in gym training of local football team	1
A run through	A conversation about the entire treatment/intervention including what is expected from the young person, the intervention components and other relevant information	---	1
Entire treatment team	Comprehensive information sharing among the entire treatment team of a YP	Exercise physiologist to inform GP and psychologist on a YP's PA intervention progress	3

Name of Code	Code Description	Examples of Code	No. of references
“More eyes are better”	The more clinician/team members are involved in a YP’s treatment, the more likely it will be a success	Psychologist, exercise physiologist and medical doctor regularly checking up on YP’s motivation, progress and needs	3
Optional peer support	Peer support as an optional treatment component	Opportunity to include peer support if relevant for YP	10

Appendix C.7

Content analysis – Spoken word

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP2: Uh, yeah, I'll go. Um, so yeah, I'm currently studying a PhD as well, um, at Vic Uni, um, where I'm looking into like psych, um, psychotic symptoms and addictions. I like my interest area. Um, and yeah, other than that, I also like teach, uh, maths to kids.	YP2: I am a student.	YP2: I am a student.	Introduction	Introduction	Organisation	Organisation
YP1: Uh, yeah, sure. Um, so I'm, I'm a student at VU, I'm currently studying psychology. Um, and yeah, I, I was just, um, referred to this study, um, by somebody, I can't remember who, cuz it was a few months ago now, but I thought, why not participate if I'm eligible? I'm in my third year at the moment, uh, with psychology as well. Yeah.	YP1: I am a student. I cannot remember how I learnt about this focus group.	YP1: I am a student.	Introduction	Introduction	Organisation	Organisation
YP3: Um, I'm a first year bachelor's of, um, sports Science at VU as well. Um, I don't know how I ended up on this. I must have completed something ages ago.	YP3: I am a student. I cannot remember how I learnt about this focus group.	YP3: I am a student.	Introduction	Introduction	Organisation	Organisation
YP3: No, I'm glad, it's something I'm interested in. I think it's, um, physical activity is great for mental health.	YP3: I am interested in this. Physical activity benefits mental health.	YP3: Physical activity benefits mental health.	Mental health benefits	Mental health	PA benefits	Why does a PA intervention make sense?
YP4: Sure. Um, well I just finished my second year of, um, bachelor of osteopathy at Vic. Um, used to play basketball but quit because. Ankle injury. Um, yeah.	YP4: I am a student. I used to play basketball.	YP4: I am a sportive student.	Introduction	Introduction	Organisation	Organisation
YP4: Uh, yes. Um, few years ago I had to. Was referred to see a psychiatrist because like I had you know mental health issues going on, but I wasn't too sure what was going on. So yeah, went to go see a psychiatrist, got diagnosed, I was like, - ah- great. But yeah, that's pretty much it.	YP 4: I was referred to a psychiatrist due to mental health issues.	YP4: I have experience with mental health services.	Service experience (neutrally described)	Service experience	Experiences	What are previous experiences of YP?
YP3: Um, I saw, uh, psychologist that was linked to my high school for a few years. Um, so found them through, through school and yeah. Saw them cuz I was struggling, yeah, throughout high school.	YP3: I was referred to a psychologist when I was struggling in high school.	YP3: I have experience with mental health services.	Service experience (neutrally described)	Service experience	Experiences	What are previous experiences of YP?

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP1: I've, I've had a few, um, different experiences over a large part of my life. Um, like when I was younger, I was. You know, a, a counselor or a psychologist would set up for me because I wasn't of age to actually really search for it myself.	YP1: Appointments were arranged for me when I was younger	YP1: I had help.	Organisational support	Service access	Service provision	What can services do?
YP1: But then, um, now that I'm, I'm an adult, um, yeah, I, it's, it's been a little trickier, um, obviously cuz you know, you have to try and find the right one.	YP1: Finding the right psychologist as adult is tricky.	YP1: Mental health access as adult is harder.	Access barrier by age	Access barrier	Barriers to service access	What barriers hinder YP to engage?
YP1: And now that I'm also studying psychology, I, I'm a little bit picky about which psychologist I'll see because, you know, they have a different, um, they each have a different sort of expertise. Um, so yeah.	YP1: Studying psychology made be picky in choosing the right psychologist.	YP1: (Psychology) knowledge can make mental health access harder.	Access barrier by knowledge	Access barrier	Barriers to service access	What barriers hinder YP to engage?
YP2: Um, in high school I had a Headspace that was like next door to my school, and they had like an agreement to let you, like leave class to go.	YP2: A headspace centre close by had an arrangement with my school.	YP 2: Easy mental health access by established arrangements.	Access by cooperation	Service access	Service provision	What can services do?
YP2: So, um, it was just really easy for me to get those kinds of services like early on. And then, yeah, whenever I felt like I would have needed to go out my way normally, I would just go through Headspace.	YP2: Having headspace close by (distance) gave me easy access. I did not have to go out of my way.	YP2: Having headspace close by (distance) gave me easy access.	Access by proximity	Service access	Service provision	What can services do?
YP1: I've, I've been with Headspace as well in the past and I, um, I would say out of, um, the few, the many few experiences I've had with mental health, um, professionals, I would say Headspace were probably the most professional and, um, yeah, they were really, they were really good. Yeah. Especially for a young person.	YP1: I have had good experiences with headspace compared to other health service. Headspace is professional and good for a young person.	YP1: Headspace is good.	Service experience (positive)	Service experience	Experiences	What are previous experiences of YP?
YP3: I've always preferred individual exercise. Like I like going to the gym. I used to do athletics. Uh, I just like individual sports. It's just preference.	YP3: I prefer individual exercise.	YP3: Preference for individual exercise.	Individual PA	Intervention preference	Preferences	What do YP want?
YP2: Yeah. Same. It's just a preference thing more for me.	YP2: I prefer individual exercise.	YP2: Preference for individual exercise.	Individual PA	Intervention preference	Preferences	What do YP want?

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP3: I think that's a good point. Like especially as if in as a health service, you can work around your own schedule a bit more if it's individual.	YP3: Individual physical activity gives you flexibility regarding your own schedule.	YP3: Individual PA allows flexibility	Individual PA (allows flexibility)	Intervention preference	Preferences	What do YP want?
YP1: Yeah, definitely. . . Yeah.	YP1: Unsupervised PA bears the risk to not actually engage in physical activity.	YP1: Unsupervised PA allows disengagement.	Inappropriate treatment model (unsupervised PA allows disengagement)	Service-induced barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP3: Yeah, I think at first it, it can be.	YP3: It is hard at first to find the motivation to do unsupervised, individual physical activity.	YP3: Unsupervised PA requires much motivation.	Inappropriate treatment model (unsupervised PA reduces motivation)	Service-induced barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP3: Um, but like once you create habits, um, you can find yourself, you know, just doing exercise because you are used to doing it.	YP3: Creating habits helps with getting used to doing exercise.	YP3: Creating habits helps with a regular PA.	Creating habits	Facilitators	Behavior change	What are previous experiences of YP?
YP3: So I think like, um, supervised to begin with can be like a good introduction. And then, you know, once someone's doing something, uh, regularly, you can leave them to it.	YP3: Supervised PA in beginning helps	YP3: Supervised PA in the beginning	Supervised PA (in beginning)	Intervention preference	Preferences	What do YP want?
	YP3: Once habits are established, preference for unsupervised PA	YP3: Preference for unsupervised PA.	Unsupervised PA (habits established)	Intervention preference	Preferences	What do YP want?
YP1: Just on, um, what you were saying before, um, like if it's planned, unsupervised, um, yeah, if it, if it's planned unsupervised, you can be lazy.	YP1: Unsupervised PA allows you to be lazy.	YP1: Unsupervised PA allows for disengagement	Inappropriate treatment model (unsupervised PA allows disengagement)	Service-induced barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP1: But if it is supervised and you have, um, someone there, I don't know if they'd be pushing you or, or what, but I've actually been injured in the past by someone not listening to me. When I'm saying, no, I'm, I'm actually, you know, I've reached as much as my body can handle here. Um, so yeah, there's that as well.	YP1: I had a bad experience with supervised PA. I got hurt because the supervisor didn’t listen.	YP1: Supervised PA can be dangerous.	Inappropriate treatment model (supervised PA can be dangerous)	Service-induced barriers	Barriers to PA engagement	What barriers hinder YP to engage?

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP2: Um, yeah, I believe like, um, yeah, if you have been, um, smoking too much like cannabis, then it will likely kill your motivation too. I know like with myself, I have to, if I wanna do some physical activity, I've gotta be like, okay, I can't smoke or do anything because I gotta do the physical activity first. Otherwise I won't be able to.	YP2: Smoking cannabis has a negative effect on motivation.	YP2: Smoking cannabis reduces motivation.	Negative impact of SU (Cannabis affects motivation)	SU barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP3: Um, I was like a pretty heavy smoker and then I started going to the gym, um, and quit just because I was getting so, um, exhausted when I was training. I was like, it is not sustainable. Yeah. My fitness was just awful. Um, yeah. So, I don't know	YP3: Smoking made me too exhausted for the gym, I had to quit.	YP3: Smoking influences fitness.	Negative impact of SU (Smoking affects fitness)	SU barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP3: I just, it helped me quit almost. Cause I just realized, uh, I'd rather exercise then.	YP3: The negative effect of smoking on my fitness helped me quit smoking.	YP3: Negative consequences help with quit motivation.	Increased quit motivation	Motivation	PA benefits	Why does a PA intervention make sense?
YP1: Yeah, I, I used to, um, I used to play and train at a, at a high level with, um, with football. AFL football. And, um, but at the time that I was training and playing at that elite level, I was, I guess I was dabbling in, uh, a few things that I shouldn't have been, um, regarding drugs.	YP1: The substance use affected my motivation and made my body tired.	YP1: Substance use affects motivation and makes tired.	Negative impact of SU (SU affects motivation/energy)	SU barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP1: Um, I remember I, I used to play, sometimes I'd play, I'd played matches without, um, without having any sleep, um, and that stuff. But yeah, it definitely catches up to you, I think.	YP1: The substances made me not needing sleep.	YP1: Substance use negatively affects sleep.	Negative impact of SU (SU affects sleep)	SU barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP1: Yeah, absolutely. I, I, I was never a smoker, but, um, being at, at a football club, you know, where everyone's sort of, um, working out. Um, I had a lot of friends who were smokers and, um, yeah, they would, they would be struggling, um, and they would be, you know, really unmotivated to, to work out as much as others were who, who didn't partake in that stuff.	YP1: Smoking negatively amplifies existing motivation barrier.	YP1: Smoking reduces motivation.	Negative impact of SU (SU affects motivation)	SU barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP1: So, yeah. The same can be applied, um, to any of, um, the session options that were listed before.	YP1: Substance use can amplify any existing barriers to PA.	YP1: Substance use can increase any PA barrier.	Negative impact of SU (SU increases barriers)	SU barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP2: Yeah. And I think it also makes it harder for any financial barriers because obviously you're spending some of that money for the substance, so you have less money to put it towards like equipment and all that.	YP2: Substance use negatively amplifies existing financial barriers to PA.	YP2: Substance use enlarges financial barrier.	Negative impact of SU (SU affects finances)	SU barriers	Barriers to service access	What barriers hinder YP to engage?

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP3: Uuum, yeah, I mean, yeah, it just tanks your motivation. I think a lot of like drinking, smoking, um, and then you are less motivated to, to exercise, exercise is harder so you don't wanna do it and it just kinda spirals.	YP3: Smoking/ drinking negatively affect motivation, which makes exercise harder, which then again further reduces motivation.	YP3: Smoking/drinking reduces motivation	Negative impact of SU (Smoking/ drinking affects motivation)	SU barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP4: Mm-hmm. I agree.	YP4: Smoking/drinking negatively affects motivation.	YP4: Smoking/drinking reduces motivation.	Negative impact of SU (Smoking/ drinking affects motivation)	SU barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP4: And definitely, yeah. The um, financial side cuz yeah, if you are already struggling but you're spending money on like smoking, drugs, all that kind of just snowballs.	YP4: Substance use negatively amplifies existing financial barriers.	YP4: Substance use enlarges financial barriers.	Negative impact of SU (SU affects finances)	SU barriers	Barriers to service access	What barriers hinder YP to engage?
YP1: Yeah, I, I personally don't think, um, the role or the, or the title that they hold matters just as long as they, they do know what they're talking about regarding exercise.	YP1: Any clinician with proficient knowledge can facilitate PA (independent of role/title).	YP1: Clinician with proficient knowledge.	Knowledgeable clinician	Clinician preferences	Preferences	What do YP want?
YP1: Like, um, whenever I've seen general practitioners in the past or, um, um, or, or things of that nature, um, yeah, they, they, they know that exercise is a good thing and they might say, oh yeah, just you know, “Have like a couple of hours each week to maintain a good, um, you know, uh, you know, good physical wellbeing”. Um, but they don't, they don't really go into more detail about that.	YP1: Practitioners are aware of PA benefits, but give only general, vague recommendations. Practitioners don’t give details.	YP1: Only vague recommendations from clinicians.	Vague recommendations	Service-induced barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP1: So I guess like if you don't, it's okay for myself, like I know a fair bit about exercise, but if you're someone that doesn't know about exercise and you're hearing that from a GP, you might be thinking, oh, okay, cool. Well, where do I start now?	YP1: Vague PA recommendations from a GP leaves individuals not knowing where to start	YP1: Clinicians should give directions	Clear directions	Clinician preferences	Preferences	What do YP want?
YP3: I think the biggest thing is whether they seem passionate about physical activity and can make you, um, want to engage. I think the title doesn't really matter that much. It's more whether they can make it engaging and show that they care about physical activity as well.	YP3: The title of a clinician does not matter as long as the person is passionate about PA and can motivate you to engage.	YP3: Clinician needs to be motivating and passionate.	Passionate clinician	Clinician preferences	Preferences	What do YP want?

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP1: Sorry. I was just gonna say like, that's, that's actually a really good point cause I've had, um, personal trainers in the past, um, that they, they have, they have a lot of knowledge of the exercise, but they're not passionate. So that makes me not motivated to actually do the exercise.	YP1: A clinician with a lot of exercise knowledge but no PA passion does not motivate to engage in PA.	YP3: Clinician needs to be passionate about PA.	Passionate clinician	Clinician preferences	Preferences	What do YP want?
YP3: Yeah. I think being given some sort of plan is, is always better than just being told, “oh, you should exercise”.	YP3: A PA plan is always better than a vague recommendation.	YP3: Clinician should give plan.	Clear directions	Clinician preferences	Preferences	What do YP want?
YP2: Yeah. And also being like able to discuss like the different types of exercise. You know, like the people who don't actually wanna just sit down and work out be like, yeah, well what sport could we look out to that you'll be interested in? And, you know, be able to discuss all those different options because it's not always clear to, you know, the, the client that they would know what's best for them.	YP2: A clinician should discuss different exercise options with a YP, to find the right option for them.	YP2: Clinician should give directions and discuss different options.	Clear directions	Clinician preferences	Preferences	What do YP want?
	YP2: Help YP find the best PA fit.	YP2: Tailored PA program for client.	Tailored PA	Intervention preference	Preferences	What do YP want?
YP1: Yeah, I feel like as if, if you were able to change, like some of your behaviors, maybe by default, um, your environment would change anyway, but maybe it might be a little harder the other way around. So, yeah. Sorry, I can't give you more on that. I need to think of it more.	YP1: Behavioral interventions are more beneficial than structural; if you change your behavior your environment changes by default.	YP1: Behavioral interventions are more beneficial than structural.	Behavior change intervention	Intervention preference	Preferences	What do YP want?
YP2: Yeah, I reckon it's, it's definitely hard. Um, like for me, I was like not exercising for a few years and then I got lucky to get into a study that paid me to exercise and then because of that, that extra motivation and all that, I was able to keep it going. But even being paid, it was really hard to get back into actually exercising and all that. Everything just seems so much tougher. They do.	YP2: Behavior change is hard. Being paid for behavior change increases the motivation.	YP2: Behavior change is hard.	Hard	Barriers	Behavior change	What are previous experiences of YP?
YP4: Oh, okay. Um, I think, yeah, if you can overcome all those barriers, then yeah, you'll definitely feel more empowered and, um, I think like over time, more inclined to keep exercising cuz yeah.	YP4: Overcoming existing barriers to PA makes you feel empowered and more inclined to keep exercising.	YP4: Doing physical activity is empowering.	Empowering	Facilitators	Behavior change	What are previous experiences of YP?

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP4: Obviously if you haven't exercised in a while and then all of a sudden, you know, you've gotta exercise, heaps, it's gonna be harder at the start.	YP4: Behavior change is hard at first	YP4: Behavior change is hard at first.	Hard	Barriers	Behavior change	What are previous experiences of YP?
	YP4: Behavior change gets easier with time.	YP4: Behavior change gets easier with time	Easier with time	Facilitators	Behavior change	What are previous experiences of YP?
YP4: But yeah, once you like get into the swing of things, definitely feel more empowered.	YP4: Behavior change gets easier with time and feels empowering.	YP4: Behavior change is empowering.	Empowering	Facilitators	Behavior change	What are previous experiences of YP?
YP3: Yeah. I think making behavioral change, you just need a bit of a push for a while and then it sticks. That's what I've always found is like you force yourself for a month and then it's smooth sailing and you get real behavioral change.	YP3: For behavioral change you have to push yourself for a while	YP3: Behavioral change required pushing oneself	Hard	Barriers	Behavior change	What are previous experiences of YP?
	YP3: After a while it is smooth sailing	YP3: Behavior change gets easier with time	Easier with time	Facilitators	Behavior change	What are previous experiences of YP?
YP3: I think it's like most habits, it, you know, most like waking up early, for example, you force yourself for like a couple of weeks	YP3: To create habits you need to force yourself at first.	YP3: Creating habits (behavior change) is hard, but achievable.	Hard	Barriers	Behavior change	What are previous experiences of YP?
	YP3: and then you're just used to it.	YP3: Behavior change get easier with time	Easier with time	Facilitator	Behavior change	What are previous experiences of YP?
YP2: Yeah, no, I, I think that it would be, um, quite good to have like some kind of exercise program.	YP2: It would be good to have an exercise program within a mental health service.	YP2: PA intervention is beneficial for SU.	Added SU benefits	SU benefits	PA intervention benefits	Why does a PA intervention make sense?

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP2: Um, maybe something that can be moulded into other interventions that already exist because, you know, we know the exercise helps with so many different things. […]	YP2: A PA program that can be moulded into existing interventions can help several mental health struggles.	YP2: PA can help with mental illness beyond SU.	Behavioural domino effect	Behavioural domino effect	PA intervention benefits	Why does a PA intervention make sense?
YP2: Um, instead of just saying, you know, "Do exercise", it's more like, "oh, here's a little program we can put you in that helps with socializing or eating healthier." Something along those lines.	YP2: Intervention can help with healthy eating	YP2: Intervention can help with healthy eating	Healthy eating	Behavioural domino effect	PA intervention benefits	Why does a PA intervention make sense?
YP2: Then it should be something maybe that we can add on to existing stuff.	YP2: PA intervention integrated with existing treatment.	YP2: PA intervention should be integrated	Psychological support/integrated PA	PA facilitator	Service provision	What can services do?
YP2: Yeah. Yeah. I think it's, it's better, you know, kind of just adding direction for people.	YP 2: A PA program can add direction for people.	PA can add direction	Adding direction	Life structure	PA intervention benefits	Why does a PA intervention make sense?
YP2: Or maybe if it's a program, you know, social, a social thing, then you can get other people who are in that program that help than just go saying, "well, maybe you should go sign up for your local sports thing." You know, it's just extra motivation, so…	YP2: In a group program other program participants can additionally motivate.	YP2: Group programs are motivating.	Motivation increase	Group benefits	PA intervention benefits	Why does a PA intervention make sense?
YP3: I definitely think so. Yeah. Um, because I feel like there's just so many more benefits to exercise than you can get from just normal, uh, mental health treatment. Through encouraging Exercise.	YP3: A PA intervention adds additional benefits to normal mental health treatment through encouraging exercise.	YP3: Integrated PA is superior to just mental health treatment.	Added SU benefits	SU benefits	PA intervention benefits	Why does a PA intervention make sense?
YP4: Definitely, yeah.	YP4: Adding a PA intervention has advantages to existing programs/	YP4: PA intervention has advantages.	Added SU benefits	SU benefits	PA intervention benefits	Why does a PA intervention make sense?
YP1: I, I think, um, I th I think it, it would be beneficial, um,	YP1: A PA intervention is beneficial to existing interventions.	YP1: PA intervention is beneficial for SU.	Added SU benefits	SU benefits	PA intervention benefits	Why does a PA intervention make sense?

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP1: but for some patients or some clients that maybe need more, more psychological help or more mental help, um, yeah, I don't think that the physical side of the intervention um, should take priority over that for some patients and some clients, especially if it's like immediate mental health treatment that they need. Um, like maybe that's like crisis intervention or something like, you know, you're not gonna tell you, you probably shouldn't be telling someone who's on the brink of suicide, uh, just gone go for a run.	YP1: A PA intervention should integrated; mental health treatment should remain the focus.	YP1: PA intervention should be integrated	Psychological support/integrated PA	PA facilitator	Service provision	What can services do?
YP1: Yeah. I think the, the ideal intervention would be one that's pretty diverse, but, um, it's just whether or not, you actually have the time and the resources to, to do that. Like bec-, you know, if, if you are someone struggling with mental health and you are, you know, yeah. If you're someone struggling socially, and that's affecting your mental health. But then all, all the exercise that you're doing is individual, then that's probably not gonna help you in a group setting.	YP1: An ideal PA intervention, if time and resources are available, would be diverse.	YP1: PA intervention needs to be diverse.	PA variety (diverse, adaptable)	Intervention preference	Preferences	What do YP want?
	YP 1: If a YP is struggling socially, the Intervention should help engage in social PA.	PA intervention should cater to current mental health needs.	Tailored PA	Intervention preference	Preferences	What do YP want?
YP1: Um, but then if you are someone that's struggling mentally when you're on your own at home a lot, and then all you're doing is, is, um, is, is group setting exercises, maybe that's, that might not be helping you when you go home. And you're, and you're alone. So I think, I think it requires, yeah, I think in with that, I think it would require sort of both.	YP1: If you are struggling when alone, the PA intervention should guide you how you can do PA when you are alone.	YP1: PA intervention should cater to current mental health needs.	Tailored PA	Intervention preference	Preferences	What do YP want?
YP1: Yeah, I think, yeah, I, I mentioned earlier, um, on one of the post-It notes that, yeah, I think variety is, variety is important,	YP1: Flexibility, adaptability and variety in PA interventions are important for struggling YP.	YP1: Variety and choice is important.	PA variety	Intervention preference	Preferences	What do YP want?
YP1: especially like if you are someone that's struggling, you're probably, you know, you're probably not inclined to want to change things.	YP1: YP struggling with mental health do not want to change behavior.	YP1: Behavior change is hard with mental illness	Mental illness	Barrier	Behavior change	What do YP want?
YP1: You know, depression can be really comfortable, for example. Um, so yeah, I th I think to, you know, someone that could, you know, be able to motivate you to say, oh, let's try this. You know, let's, let's do that. Um, might be beneficial.	YP1: Individuals suffering of depression can benefit from additional motivators.	YP1: Clinician needs to be motivating.	Motivating clinician	Clinician preferences	Preferences	What do YP want?

Meaning Unit	Condensed Meaning Unit 1	Condensed Meaning Unit 2	Code	Sub-Category	Category	Theme
YP1: I feel as if the peer support worker role would sort of maybe be covered a little already by, by the person who's maybe giving you advice on the exercise or whatever, like you know, when, when I've had personal trainers in the past, they've als they've almost been, um, psychologists as well, because they're talking about, you know, you're talking to them about your day, how are you going? And they're sort of giving you advice while telling you what exercises to do and how to do it.	YP1: Peer support worker are redundant, because PA facilitator helps with PA participation and mental health.	YP1: Peer support worker may be redundant.	Optional peer support	Facilitation preference	Preferences	What do YP want?
YP1: So I, yeah, I kind of feel as if maybe, um, in some, um, exercise interventions, a peer support worker might not be needed. Like, it's, it's obviously it probably beneficial, but maybe not needed. Especially if you know resources and time, um, might be an issue. Yeah.	YP1: A peer support worker may not be needed when resources/ time are limited. A peer support worker may be beneficial.	YP1: Peer support worker may be redundant.	Optional peer support	Facilitation preference	Preferences	What do YP want?
YP1: I think it depends on how trustworthy their advice or their, um, their, uh, related experiences are. Um, yeah.	YP1: A peer support workers relevance depends on how trustworthy their advice/ related their experiences are.	YP1: Advice of peer support worker possibly irrelevant.	Optional peer support	Facilitation preference	Preferences	What do YP want?
YP3: I think it would be useful, um, especially if you're doing some sort of, um, physical activity intervention where you're not working with other people, um, as much. So, if you're not, you know, working with a team or, or, um, like a personal trainer in all your sessions, um, having that option would be better.	YP3: A peer worker may be beneficial when doing individual, P (no personal trainer, no team).	YP3: Peer worker beneficial for unsupervised, individual PA.	Optional peer support	Facilitation preference	Preferences	What do YP want?
YP1: I was just gonna say, yeah, just before I lose my trail of thought with it, um, just with the, the peer support worker, like it's, and you know, or, um, someone with lived experiences, um, lived experience, um, it would be anecdotal, you know, what, what they're talking about. So their, their experiences might not be relevant to you.	YP1: Lived experience of peer support worker is anecdotal and not relevant to YP.	YP1: Peer support worker possibly irrelevant.	Optional peer support	Facilitation preference	Preferences	What do YP want?
YP1: You know, they might say, “oh yeah, you should go about things this way”, but then, I mean, you know, they might be completely different to you, so you might take their advice on board, apply it to your life, or apply it to your exercise or whatever. And it might not work out as well as it did for that person that was giving that advice, so, yeah.	YP1: Advice of peer support worker might not work for YP.	YP1: Advice of peer support worker possibly irrelevant.	Optional peer support	Facilitation preference	Preferences	What do YP want?

Appendix C.8

Qualitative content analysis – Written word

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
YP1: Supervised as I have another person other than myself to hold me accountable.	YP1: A supervisor can hold me accountable.	YP1: Supervision holds accountable.	Supervised PA (for accountability)	Intervention preference	Preferences	What do YP want?
YP2: Planned unsupervised, unless its with a PT.	YP2: I prefer planned, unsupervised PA.	YP2: Preference for planned, unsupervised PA.	Planned, unsupervised PA	Intervention preference	Preferences	What do YP want?
YP3: planned unsupervised with occasional check ins.	YP3: Preference for planned, unsupervised PA.	YP3: Preference for planned, unsupervised PA.	Planned, unsupervised PA	Intervention preference	Preferences	What do YP want?
YP4: Planned Unsupervised	YP4: Preference for planned, unsupervised PA.	YP4: Preference for planned, unsupervised PA.	Planned, unsupervised PA	Intervention preference	Preferences	What do YP want?
YP4: Physiologist	YP 4: Preference for physiologist facilitator.	YP4: Preference for physiologist facilitator.	Physiologist facilitator	Facilitation preference	Preferences	What do YP want?
YP2: Physiologist/Personal trainer with mental health education	YP2: Preference for physiologist facilitator.	YP2: Preference for physiologist facilitator.	Physiologist facilitator	Facilitation preference	Preferences	What do YP want?
YP1: Physiologist as it is my understanding they would better understand what I need in the exercising department.	YP1: Preference for physiologist facilitator.	YP1: Preference for physiologist facilitator.	Physiologist facilitator	Facilitation preference	Preferences	What do YP want?
YP4: Physiologist	YP4: Preference for physiologist facilitator.	YP4: Preference for physiologist facilitator.	Physiologist facilitator	Facilitation preference	Preferences	What do YP want?
YP2: Tailored. Would rather be motivated to do a sport, over a structured exercise plan	YP2: Preference for tailored PA.	YP2: Preference for tailored PA.	Tailored PA	Intervention preference	Preferences	What do YP want?
YP3: tailored to persons needs and wants for greatest enjoyment and retention	YP3: Preference for tailored PA.	YP3: Preference for tailored PA.	Tailored PA	Intervention preference	Preferences	What do YP want?
YP1: Tailored as my exercise needs are different to others.	YP1: Preference for tailored PA.	YP1: Preference for tailored PA.	Tailored PA	Intervention preference	Preferences	What do YP want?
YP4: Individual	YP4: Preference for individual PA.	YP4: Preference for individual PA.	Individual PA	Intervention preference	Preferences	What do YP want?

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
YP3: individual activity	YP3: Preference for individual PA.	YP3: Preference for individual PA.	Individual PA	Intervention preference	Preferences	What do YP want?
YP2: Individual	YP2: Preference for individual PA.	YP2: Preference for individual PA.	Individual PA	Intervention preference	Preferences	What do YP want?
YP1: Individual as there won't always be a readily available group handy to help motivate me.	YP1: Preference for individual PA.	YP1: Preference for individual PA.	Individual PA	Intervention preference	Preferences	What do YP want?
YP1: In-person as I'm a strong advocate for all things anti-technology when face-to-face is an option.	YP1: Preference for in-person facilitation.	YP1: Preference for in-person facilitation.	In-person facilitation.	Intervention preference	Preferences	What do YP want?
YP4: In person	YP4: Preference for in-person facilitation.	YP4: Preference for in-person facilitation.	In-person facilitation.	Intervention preferences	Preferences	What do YP want?
YP2: Mixed in-person and online	YP2: Preference for mixed in-person and online facilitation.	YP2: Preference for mixed in-person and online facilitation.	Mixed facilitation.	Intervention preference	Preferences	What do YP want?
YP3: online with occasional in-person	YP3: Preference for mixed in-person and online facilitation.	YP3: Preference for mixed in-person and online facilitation.	Mixed facilitation.	Intervention preference	Preferences	What do YP want?
YP4: Behaviour change	YP4: Preference for behavior change intervention.	YP4: Preference for behavior change intervention.	Behavior change intervention	Intervention preference	Preferences	What do YP want?
YP1: Behaviour change	YP1: Preference for behavior change intervention.	YP1: Preference for behavior change intervention.	Behavior change intervention	Intervention preference	Preferences	What do YP want?
YP2: Be motivated to keep up a exercise plan after treatment	YP2: Behavior change that leads to behaviral maintenance	YP2: Behavioral maintenance	Behavior change intervention	Intervention preference	Preferences	What do YP want?
YP3: encouraging exercise as a habit/hobby	YP3: establish a behavioral habit	YP3: Establish behavioral change	Behavior change intervention	Intervention preference	Preferences	What do YP want?
YP1: Cultural and gender barriers (I think we tend to feel more comfortable exercising in the same environment as people who are like us)	YP1: Cultural barriers to PA	YP1: Cultural barriers to PA	Cultural barriers	Social barriers	Barriers to PA engagement	What barriers hinder YP to engage?

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
	YP1: Gender barriers to PA	YP1: Gender barriers to PA	Gender barriers	Social barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP2: Social barriers (Confidence & fitting in with team sports)	YP2: Social barriers to PA	YP2: Social barriers to PA	Social barriers	Social barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP3: Distance from closest gym/etc	YP3: Distance barrier to PA	YP3: Proximity barrier to PA	Proximity barrier	Logistical barriers	Barriers to service access	What barriers hinder YP to engage?
YP2: Not making progress in chosen sport	YP3: Lack of progress barrier	YP3: Lack of progress barrier	Progress barrier	Other barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP3: Getting bored of the activity	YP3: Lack of variety barrier	YP3: Lack of variety barrier	Variety barrier	Other barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP4: Transportation barriers - May not have a way to get to where they need to be	YP4: Transportation barrier	YP4: Transportation barrier	Transportation barrier	Logistical barriers	Barriers to service access	What barriers hinder YP to engage?
YP1: Drugs are definitely a barrier to exercise, especially in the days after drug use when a person is coming down from the high and experiencing a lack of energy.	YP1: Substance use may affect energy levels.	YP1: Substance induced lack of energy	Negative impact of SU (Drug comedown)	SU barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP4: availability of resources	YP4: Lack of resources barrier	YP4: Lack of resources barrier	Resources barrier	Logistical barriers	Barriers to service access	What barriers hinder YP to engage?
YP1: Sometimes I just like to work out on my own and not deal with the hustle and bustle of a gym, so group dynamics at play may affect my motivation for exercise.	YP1: Group dynamics may negatively affect PA motivation.	YP1: Group dynamics barrier affect motivation	Group dynamics barrier	Social barriers	Barriers to PA engagement	What barriers hinder YP to engage?
YP1: Notifications on phones/computers can disrupt online or cell-based exercise sessions.	YP1: Technology may disturb physical activity.	YP1: Technology-based interruptions.	Technological barrier	Other barriers	Barriers to PA engagement	What barriers hinder YP to engage?

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
YP4: Have services available for those who may be struggling financially	YP4: PA programs for YP who are struggling financially.	YP4: Low cost/free PA options	Low cost PA	PA facilitators	Service provision	What can services do?
YP3: making the benefits of physical activity aware to me	YP3: Learning about PA benefits	YP3: Information on PA	Informative education (on PA benefits)	PA facilitators	Service provision	What can services do?
YP3: Not jumping into the deep end with exercise intensity.	YP3: Slowly increasing exercise intensity	YP3: Gradual PA increase	Gradual PA increase	PA facilitators	Service provision	What can services do?
YP2: Psychological support overall that also can refer back to how that can help imporve access to exercise	YP2: PA access through improved mental health	YP2: PA access through improved mental health	Psychological support	PA facilitators	Service provision	What can services do?
YP1: I think it would be extremely beneficial if someone who was an expert in exercise was readily available at the health service. I also believe in the strength of measurable goal-setting as a real motivator for physical and mental progress.	YP1: Availability of exercise expert in health service.	YP1: Availability of exercise expert.	Expert availability	PA facilitators	Service provision	What can services do?
	YP1: Measurable goal-setting as a motivator.	YP1: Measurable goal-setting.	Goal-setting	PA facilitators	Service provision	What can services do?
YP1: I think variety in exercise is necessary for myself so the exercises don't become monotonous and boring, which would decrease my motivation levels.	YP1: Variety in exercise as motivator.	YP1: Variety in exercise.	PA variety	PA facilitators	Service provision	What can services do?
YP2: Help with organise times that I could do exercise	YP2: Help with organisation of PA	YP2: Help with organisation of PA	Organisational support	PA facilitators	Service provision	What can services do?
YP2: Being explaining the effects substances can have on exercise performance	YP2: Education on substance-PA relationship/interactions	YP2: Information on PA/substances	Informative education (PA/SU interaction)	PA facilitators	Service provision	What can services do?
YP1: I would feel valued and therefore more likely to continue engaging.	YP1: Service-led barrier reductions leads to feeling valued	YP1: Service-led barrier reductions leads to feeling value	Feeling of appreciation (Feeling valued)	Mental health	Service-led barrier reduction	What can services do?
YP2: Value exercise more. would be a small push in doing more exercise.	YP2: Barrier reductions makes me value exercise more	YP2: Barrier reductions increases perceived value	Value increase	Behavioral consequence	Service-led barrier reduction	What can services do?

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
YP4: Would definitely make me want to engage more often - I don't really have to worry about anything	YP4: Little/less barriers would make me engage more often.	YP4: Barrier reduction increases engagement	Engagement/motivation increase	Behavioral consequence	Service-led barrier reduction	What can services do?
	Not have to worry about anything	Less worry	Positive feeling (less worry)	Mental health	Service-led barrier reduction	What can services do?
YP3: treatment that values my exercise enjoyment	YP3: Treatment that values exercise enjoyment feels great	YP3: Barrier reduction feels great	Positive feeling	Mental health	Service-led barrier reduction	What can services do?
YP3: and creating routine would be great	YP3: Creating a routine	YP3: PA helps with routine	Regular routine	Life structure	PA benefits	Why does a PA intervention make sense?
YP3: regular routine in my life	YP3: PA creates life routine	YP3: PA aids regular routine	Regular routine	Life structure	PA benefits	Why does a PA intervention make sense?
YP2: Can carry that dopamine hit into other boring tasks throughout the day	YP2: PA increases dopamine, which helps with other boring tasks	YP2: PA increases dopamine	Dopamine increase	Physiological benefits	PA benefits	Why does a PA intervention make sense?
YP4: Gives me a sense of responsibility	YP4: Sense of responsibility.	YP4: Sense of responsibility.	Sense of responsibility	Life structure	PA intervention benefits	Why does a PA intervention make sense?
YP2: Have more energy throughout the day	YP2: PA increases energy	YP2: Energy increase.	Energy increase	Physiological benefit	PA benefits	Why does a PA intervention make sense?
YP2: Encourages me to eat healthy/eat enough	YP2: PA can help increase other health behavior	YP2: PA increases other health behavior	Healthy eating	Behavioral domino effect	PA benefits	Why does a PA intervention make sense?
YP2: Encourages me to socialise/share my accomplishments with others	YP 2: Encourages social interaction	YP2: Social encouragement	Social encouragement	Behavioral domino effect	PA benefits	Why does a PA intervention make sense?

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
YP3: encourages drive/motivation in other activities	YP3: Encourages behavioral activation	YP3: Increased motivation in other activities	Behavioral domino effect	Behavioral domino effect	PA benefits	Why does a PA intervention make sense?
YP4: Working out in a group/group setting can improve social skills	YP4: Improved social skills	YP4: Improved social skills	Social encouragement	Group benefits	PA intervention benefits	Why does a PA intervention make sense?
YP4: With a tailored program - It makes it feel more personal and individual rather than an exercise program just given to everyone	YP4: Tailored programs feel personal.	YP4: Tailored feels personal. Preference for tailored.	Feeling of appreciation (tailored PA)	Tailored PA	Service provision	What can services do?
YP1: If it's individual as opposed to group, then measurable goal setting for exercises is less of a competition amongst the group.	YP1: Individual PA is less competitive	YP1: Individual PA is less competitive	Less competitive (individual PA)	Tailored PA	Service provision	What can services do?
Y3: Eating more healthily	YP3: PA can help increase eating healthy	YP3: PA increases eating healthy	Healthy eating	Behavioral domino effect	PA benefits	Why does a PA intervention make sense?
YP 3: form new relationships with people that do the same activity	YP3: Group-based PA encourages relationship building	YP3: Encourages relationship building	Social encouragement (group-based PA)	Group benefits	PA intervention benefits	Why does a PA intervention make sense?
YP1: Supervised is beneficial as I have real-time feedback on what I am doing correctly or incorrectly regarding the exercise.	YP1: Supervised PA allows for real-time feedback on PA	YP1: Supervised PA for feedback.	Allows feedback (supervised PA)	Tailored PA	Service provision	What can services do?
YP1: Behaviour change might be more beneficial as it empowers you a little more	YP1: Behavior change is empowering.	YP1: Behavior change is empowering.	Empowering	Mental health	PA benefits	Why does a PA intervention make sense?
YP1: If it's tailored I feel more valued, instead of if it's standardised I may feel like just another client/patient.	YP1: Tailored PA makes me feel more valued.	YP1: Tailored PA increases valued feeling.	Feeling valued (Tailored PA)	Tailored PA	Service provision	What can services do?
YP4: If people are struggling to eat healthily they could integrate a meal plan	YP4: PA intervention can help with eating healthy	YP4: PA encourages health eating	Healthy eating	Behavioral domino effect	PA intervention benefits	Why does a PA intervention make sense?

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
YP1: Prizes/rewards for completing personal exercise goals may be motivating for some.	YP1: Rewards for completed goals are motivating	YP1: Rewards for goal completion	Reward system	Engagement aid	Service provision	What can services do?
YP3: testimony of other people's positive experiences.	YP3: Other's people's testimony	YP 3: People's testimony	Positive testimonies	Engagement aid	Service provision	What can services do?
YP2: use exercise programs as to help improve other targeted interventions	YP2: Behavioral activation may benefit other interventions	YP2: Behavioral activation through physical activity	Behavioral domino effect	Engagement aid	Service provision	What can services do?
YP2: Could use exercise to help with treatment for social issues/loneliness	YP2: Use exercise to help with other issues (loneliness)	YP2: Improved social skills	Behavioral domino effect/ Social encouragement	Engagement aid	Service provision	What can services do?
YP3: creating a network of people doing similar exercise.	YP3: Creating network of exercising people.	YP3: Connect people through network	Social connection	Engagement aid	Service provision	What can services do?
YP1: Education and awareness is key to integration. Statistics help also.	YP1: Education and statistics help with PA integration.	YP1: Education and statistics help	Informative education (to help PA integration)	Engagement aid	Service provision	What can services do?
YP1: I would be more inclined to engage with a specifically focused PA intervention as a 'jack-of-all trades but master of none' approach might not, considering I already have a bit of an understanding of exercise, the mind, and the body, and could therefore probably do that approach myself, saving myself money in the process.	YP1: Specifically focussed PA intervention would make me want to engage with service.	YP1: Focussed PA intervention increases engagement.	Engagement increase	Tailored PA	Service provision	What can services do?
YP4: Would make it feel like they care a bit more - I would be more inclined to engage with that program than others	YP4: Tailored PA according to preferences make me feel cared for.	YP4: Tailored PA	Feeling of appreciation (Feeling cared for)	Tailored PA	Service provision	What can services do?
YP2: It would make me care more about exercise and lead to greater motivation	YP2: Tailored PA according to preferences motivates me	YP2: Tailored PA increases motivations	Engagement/motivation increase	Tailored PA	Service provision	What can services do?
YP3: I would be much more likely to participate if I'm engaging with others from the start	YP3: Social connection increases engagement	YP3: Social connection helps	Social connection	Engagement aid	Service provision	What can services do?
YP3: and hearing positivity about treatment	YP 3: Other's people's testimonies	YP3: People's testimony	Positive testimonies	Engagement aid	Service provision	What can services do?

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
YP1: Funding, resources and time.	YP1: Funding, resources and time needed for highly tailored programs.	YP1: Funding, resources, time	Increased resources	Integrating choice	Service processes	What can services do?
YP2: A screening procedure to tailor individual preferences	YP2: Screening procedure for individual preferences.	YP2: Screening for preferences	Screening procedure	Integrating choice	Service processes	What can services do?
YP3: finding a model that meets the wants of the majority of participants	YP3: Model that caters to client majority.	YP3: Universal, adaptable model	Universal model	Integrating choice	Service processes	What can services do?
YP1: Clients could sign up to a tailored aspect of a variety of different approaches at whatever time they feel comfortable (One week they might feel like doing group exercises, the next they might want to just work out alone).	YP1: Pool of various different exercises; clients can choose what to sign up to.	YP1: Pool of options to choose from	PA variety	Integrating choice	Service processes	What can services do?
YP2: At the start, after an information session	YP2: At information session at start	YP2: Before treatment starts	At the start	Integrating choice	Service processes	What can services do?
YP1: Continuously from start to finish	YP1: Continuously, start to finish	YP1: Continuously, start to finish	continuously	Integrating choice	Service processes	What can services do?
YP3: after having already engaged with treatment where PA intervention seems appropriate	YP3: After having engaged in mental health treatment	YP3: Where appropriate	Where appropriate	Integrating choice	Service processes	What can services do?
YP4: When discusiing the treatment at the start would probably be the best time - helps decided what program best suits	YP4: Discus options before treatment start	YP4: At the start	At the start	Integrating choice	Service processes	What can services do?
YP3: hearing about how this treatment may suit my needs or may have benefits more personalised to me	YP3: Information on personal treatment benefits	YP3: Information on personal treatment benefits	Informative education (personal treatment benefits)	Decision aid	Service provision	What can services do?
YP2: Be told the available options that are possible, since it is not feastible to have every exercise option	YP2: Information on available options	YP2: Information on available options	Available options	Decision aid	Service provision	What can services do?
YP2: Having more options would encourage me to try out the program	YP2: Having choice encourages engagement	YP2: Choice encourages engagement	PA variety	Decision aid	Service provision	What can services do?

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
YP2: Having different types of activities to choose from.	YP 2: Having choice encourages engagement	YP2: Choice encourages engagement	PA variety	Decision aid	Service provision	What can services do?
YP2: Maybe have the program be connected to existing local sport teams	YP 2: Connection to local sports team	YP2: Connection to local sports team	Local connection	Decision aid	Service provision	What can services do?
YP4: Information regarding how this is going to benefit me in the long run	YP 4: Information on personal long-term benefits	YP4: Information on long-term benefits	Informative education (personal long-term benefits)	Decision aid	Service provision	What can services do?
YP4: sort of like a whole run through	YP 4: A run-through would help with decision what options to try	YP4: A run-through would help with decision what options to try	A run through	Decision aid	Service provision	What can services do?
YP3: If that information is helpful to those members I wouldn't mind them knowing.	YP3: Comfortable with PA progress/ information sharing among treatment team.	YP3: Comfortable with treatment information sharing.	Entire treatment team	Information sharing	Service processes	What can services do?
YP1: I think the service team members should only be privy to information that actually impacts or is relevant to their individual work.	YP1: Information sharing in among treatment team only where relevant.	YP1: Information sharing only where relevant.	Where appropriate	Information sharing	Service processes	What can services do?
YP2: Maybe have a summary sheet done by a physio that can be shared with other members of the service team"	YP2: Information sharing among treatment team via summary sheet	YP2: Comfortable with treatment information sharing.	Entire treatment team	Information sharing	Service processes	What can services do?
YP4: I think anyone involved with my mental health treatment, I would be comfortable with them knowing	YP4: Comfortable with PA progress/ information sharing among treatment team.	YP4: Comfortable with treatment information sharing.	Entire treatment team	Information sharing	Service processes	What can services do?
YP1: Yes, as more eyes should equal more motivation. Findings and experiences from other service team members regarding the client could also prompt the clinician or physiologist to adjust their treatment plans.	YP1: More service team members checking in leads to more motivation. High level of cooperation can lead to maximum tailored treatment plans.	YP1: Large service team improves service provision.	“More eyes are better”	Progress checking	Service processes	What can services do?
YP2: Yes, as it could help identify if their are any barriers or benefits the are occurring	YP2: Multiple team members help identify occurring benefits/barriers.	YP2: Large service team improves service provision.	“More eyes are better”	Progress checking	Service processes	What can services do?

Meaning unit	Condensed meaning unit 1	Condensed meaning unit 2	Code	Sub-Category	Category	Theme
YP4: I think so, personally the more people checking in would keep me more motivated	YP4: The more health workers/clinicians checking in on PA treatment progress, the more motivation.	YP4: Large service team improves service experience.	“More eyes are better”	Progress checking	Service processes	What can services do?
YP2: It would be useful to have it as an optional choice	YP2: Peer support workers as optional choice.	YP2: Peer support workers as optional choice.	Optional peer support	Facilitation preference	Preferences	What do YP want?
YP3: I would prefer to have that option as their own testimony could be motivating	YP3: Optional peer support worker can be motivating.	YP3: Optional peer support worker can be motivating.	Optional peer support	Facilitation preference	Preferences	What do YP want?
YP4: Would definitely be good as an option as it wouldn't be the preferred choice for everyone	YP4: Peer support worker as optional choice.	YP4: Peer support workers as optional choice.	Optional peer support	Facilitation preference	Preferences	What do YP want?
YP1: I personally don't see the point in a peer support worker for myself in an exercise environment, but I can see how it would be beneficial to some if the other service team members aren't adequately supporting the client/patient.	YP1: Peer support workers may be beneficial under certain circumstances.	YP1: Peer support workers as optional choice.	Optional peer support	Facilitation preference	Preferences	What do YP want?