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## REVIEW

# 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

## 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, SPORT-Discus 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](http://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](http://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 maintenance 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

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

Reference	Behaviour change techniques	Participation rate	Maintenance
An et al. (2013)	<ul style="list-style-type: none"> <li>1. Provide information on consequences of behaviour in general</li> <li>5. Goal setting (behaviour)</li> <li>8. Barrier identification/ problem-solving</li> <li>10. Prompt review of behavioural goals</li> <li>16. Prompt self-monitoring of behaviour</li> <li>19. Provide feedback on performance</li> <li>28. Facilitate social comparison</li> <li>29. Plan social support/ social change</li> <li>37. Motivational interviewing</li> </ul>	<ul style="list-style-type: none"> <li>9360 eligible individuals, 2136 (22.8%) consented online</li> <li>1698 reached per phone and assigned to study arm</li> <li>80% completed at least 4/6 web sessions and weekly check-in surveys</li> <li>80% retention rate for 7 week follow-up</li> <li>75% retention rate for 12 week follow-up</li> </ul>	Up to 30% of individuals maintained smoking abstinence until week 12.
Correia et al. (2005)	<ul style="list-style-type: none"> <li>5. Goal setting (behaviour)</li> <li>16. Prompt self-monitoring of behaviour</li> <li>17. Prompt self-monitoring of behavioural outcome (Monitoring of behaviour and substance intake)</li> <li>25. Agree behavioural contract</li> </ul>	“Five of the 133 initial participants did not return for the follow-up assessment session.”	Not specified
Daniel et al. (2007)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	Not specified (45 overall participants)	Not specified
Daniel et al. (2006)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	Not specified (40 overall participants)	Not specified
Everson et al. (2006)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	Not specified (37 overall participants)	Not specified
Everson et al. (2008)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	Not specified (45 overall participants)	Not specified
Faulkner et al. (2010)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	Not specified (19 overall participants)	Not specified
Fishbein et al. (2016)	<ul style="list-style-type: none"> <li>5. Goal setting (behaviour)</li> <li>9. Set graded tasks</li> <li>15. Prompting generalization of target behaviour</li> <li>21. Provide instruction on how to perform the behaviour</li> <li>22. Model/Demonstrate the behaviour</li> <li>26. Prompt practice</li> <li>28. Facilitate social comparison</li> <li>36. Stress management. emotional control training</li> </ul>	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)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	Not specified (8 overall participants)	Not specified
Blank et al. (2017); Horn et al. (2013); Horn et al. (2011)	<ul style="list-style-type: none"> <li>1. Provide information on consequences of behaviour in general</li> <li>6. Goal setting (outcome)</li> <li>9. Set graded tasks</li> <li>16. Prompt self-monitoring of behaviour</li> <li>28. Facilitate social comparison</li> <li>35. Relapse prevention/coping planning</li> <li>36. Stress management/ emotional control training</li> </ul>	<ul style="list-style-type: none"> <li>40/ 60 selected schools agreed to participate, 21 schools dropped out due to time or recruitment issues.</li> <li>19 final schools, 233 participants</li> <li>3 months follow up: 75% retention rate for complete data (174/233 students)</li> <li>6 months follow up: 63% retention rate for complete data (64/233 students)</li> </ul>	Not specified

TABLE 2 (Continued)

Reference	Behaviour change techniques	Participation rate	Maintenance
Kerr et al. (2013)	<ul style="list-style-type: none"> <li>1. Provide information on consequences of behaviour in general</li> <li>2. Provide information on consequences of behaviour to the individual</li> <li>4. Provide normative information about others' behaviour</li> <li>5. Goal setting (behaviour)</li> <li>21. Provide instruction on how to perform the behaviour</li> <li>22. Model/Demonstrate the behaviour</li> <li>28. Facilitate social comparison</li> </ul>	<ul style="list-style-type: none"> <li>1796 participants in total</li> <li>1654 participants attended <math>\geq 1</math> workshop</li> <li>1542 (93%) submitted 3-month data, 1512 (91%) submitted 6-month data and 1495 (90%) submitted 12-month data</li> </ul>	<p>“Although the PHAT program was brief, it elicited greater scores for health knowledge for at least one year after implementation.” (p. 198)</p>
Lane et al. (2012)	<ul style="list-style-type: none"> <li>1. Provide information on consequences of behaviour in general</li> <li>2. Provide information on consequences of behaviour to the individual</li> <li>4. Provide normative information about others' behaviour (all conditions)</li> <li>5. Goal setting (behaviour)</li> <li>6. Goal setting (outcome)</li> <li>9. Set graded tasks (self-management plan)</li> <li>21. Provide instruction on how to perform behaviour (blood alcohol calculations)</li> <li>28. Facilitate social comparison</li> </ul>	<ul style="list-style-type: none"> <li>118 students participated in training sessions, 2 students were missing data, 13 students never presented for subsequent classes</li> <li>Final sample: <math>N = 103</math></li> </ul>	Not specified
Melamed et al. (2022)	<ul style="list-style-type: none"> <li>1. Provide information on consequences of behaviour in general (E-platform)</li> <li>5. Goal setting (behaviour)</li> <li>10. Prompt review of behavioural goals (coach sessions)</li> <li>36. Stress management/emotional control training (Part of NAVIGATE)</li> </ul>	<ul style="list-style-type: none"> <li>192 (37.6%) eligible, 70 (36.5%) enrolled and randomized.</li> <li>21 participants in total (both intervention and control group) completed the 24-week follow up</li> <li>intervention group (high intensity): 62% completed at least half of the 12 weekly calls offered, 21% completed 10 or more weekly calls</li> </ul>	Not specified
Murphy et al. (1986)	<ul style="list-style-type: none"> <li>16. Prompt self-monitoring of behaviour (daily journals)</li> <li>20. Provide information on where and when to perform the behaviour</li> <li>21. Provide instruction on how to perform the behaviour</li> <li>22. Model/Demonstrate the behaviour</li> <li>26. Prompt practice (meditation)</li> <li>28. Facilitate social comparison</li> </ul>	<ul style="list-style-type: none"> <li>60 participants eligible</li> <li>12 participants withdrew due to group assignment, 2 participants excluded due to physical conditions, 3 drop-outs during intervention phase</li> <li>Follow up: 31 of 43 baseline participants</li> </ul>	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)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	23 participants provided complete data	Not specified
Parker et al. (2016)	<ul style="list-style-type: none"> <li>1. Provide information on consequences of behaviour in general</li> <li>5. Goal setting (behaviour)</li> <li>6. Goal setting (outcome)</li> </ul>	<ul style="list-style-type: none"> <li>176 consenting participants</li> <li>60.2% (106) completed all 6 intervention sessions</li> <li>Incomplete data/ drop-outs: 9.7% (17) <math>\leq 6</math> sessions due to</li> </ul>	Not specified

(Continues)

TABLE 2 (Continued)

Reference	Behaviour change techniques	Participation rate	Maintenance
	<ul style="list-style-type: none"> <li>7. Action planning</li> <li>8. Barrier identification/problem solving</li> <li>10. Prompt review of behavioural goals</li> <li>16. Prompt self-monitoring of behaviour</li> </ul>	<ul style="list-style-type: none"> <li>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.</li> </ul>	
Prapavessis et al. (2014)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	N = 30 total sample	Not specified
Prince et al. (2020)	<ul style="list-style-type: none"> <li>16. Prompt self-monitoring of behaviour</li> <li>19. Provide feedback on performance</li> <li>21. Provide instruction on how to perform the behaviour</li> <li>26. Prompt practice</li> <li>35. Relapse prevention/coping planning</li> <li>37. Motivational interviewing</li> </ul>	<ul style="list-style-type: none"> <li>46 individuals invited to participate</li> <li>9 participants withdrew</li> <li>Final sample N = 37</li> </ul>	Not specified
Rotheram-Borus et al. (2016)	<ul style="list-style-type: none"> <li>1. Provide information on consequences of behaviour in general (informal conversations)</li> <li>5. Goal setting (behaviour)</li> <li>6. Goal setting (outcome)</li> <li>8. Barrier identification/problem solving</li> <li>13. Provide rewards contingent on successful behaviour</li> <li>15. Prompting generalization of a target behaviour</li> <li>24. Environmental restructuring</li> <li>26. Prompt practice</li> <li>28. Facilitate social comparison</li> <li>29. Plan social support/social change</li> <li>40. Stimulate anticipation of future rewards</li> </ul>	<ul style="list-style-type: none"> <li>Of individuals invited to participate (more than 98% of men approached agreed to participate)</li> <li>95% completed post assessment</li> <li>15% (11) men did not attend any practice</li> <li>71% attended regularly</li> <li>15% (11) men did not attend any practice</li> </ul>	Not specified
Scott and Myers (1988)	<ul style="list-style-type: none"> <li>5. Goal setting (behaviour)</li> <li>21. Provide instruction on how to perform the behaviour</li> <li>22. Model/Demonstrate the behaviour</li> <li>28. Facilitate social comparison</li> </ul>	<ul style="list-style-type: none"> <li>74 participants final sample</li> <li>Complete data (pre-port) only for 36 individuals</li> </ul>	Not specified
Stanley et al. (2017)	<ul style="list-style-type: none"> <li>1. Provide information on consequences of behaviour in general</li> <li>4. Provide normative information about others' behaviour</li> <li>28. Facilitate social comparison</li> </ul>	<ul style="list-style-type: none"> <li>99% of students approached agreed to participate (18 segregated classrooms (10 female, 8 male)</li> <li>439 baseline respondents, 394 post-surveys</li> </ul>	Not specified
Janse Van Rensburg and Taylor (2008)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	Not specified (23 overall participants)	Not specified
Taylor et al. (2006); Taylor et al. (2005)	<ul style="list-style-type: none"> <li>21. Provide instruction on how to perform the behaviour</li> </ul>	Not specified (15 overall participants)	Not specified
Tesler et al. (2018)	<ul style="list-style-type: none"> <li>1. Provide information on consequences of behaviour in general</li> <li>21. Provide instruction on how to perform the behaviour</li> <li>22. Model/Demonstrate the behaviour</li> </ul>	<ul style="list-style-type: none"> <li>80 adolescents approached, 76 consented</li> <li>Total N = 76</li> </ul>	Not specified

TABLE 2 (Continued)

Reference	Behaviour change techniques	Participation rate	Maintenance
Weinstock et al. (2014)	<ul style="list-style-type: none"> <li>• 28. Facilitate social comparison</li> <li>• 1. Provide information on consequences of behaviour in general</li> <li>• 2. Provide information on consequences of behaviour to the individual</li> <li>• 4. Provide normative information about others' behaviour</li> <li>• 5. Goal setting (behaviour)</li> <li>• 7. Action planning</li> <li>• 10. Prompt review of behavioural goals</li> <li>• 13. Provide rewards contingent on successful behaviour</li> <li>• 25. Agree behavioural contract</li> <li>• 37. Motivational interviewing</li> </ul>	<ul style="list-style-type: none"> <li>• 31 students (of 52 eligible), 8.8% of all individuals screened</li> </ul>	<p>“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)</p>
Weinstock et al. (2016)	<ul style="list-style-type: none"> <li>• 5. Goal setting (behaviour)</li> <li>• 7. Action planning</li> <li>• 8. Barrier identification/ problem solving</li> <li>• 10. Prompt review of behavioural goals</li> <li>• 12. Prompt rewards contingent on effort or progress towards behaviour</li> <li>• 13. Provide rewards contingent on successful behaviour</li> <li>• 25. Agree behavioural contract</li> <li>• 37. Motivational interviewing</li> </ul>	<ul style="list-style-type: none"> <li>• Total of N = 70 participants</li> <li>• Completion of one MI session: 100%</li> <li>• Completion of two MI sessions: 91.4%</li> <li>• 89% of participants attended all 8 EC sessions</li> <li>• 60 participants completed 6-month follow up</li> <li>• Both conditions reported moderate to strong satisfaction</li> </ul>	<p>“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)</p>
Wilson et al. (2018)	<ul style="list-style-type: none"> <li>• 21. Provide instruction on how to perform the behaviour</li> </ul>	N/a (46 overall participants of 74 interested individuals)	Not specified
(Ybarra et al., 2013)	<ul style="list-style-type: none"> <li>• 1. Provide information on consequences of behaviour in general</li> <li>• 4. Provide normative information about others' behaviour</li> <li>• 29. Plan social support/social change</li> <li>• 35. Relapse prevention/coping planning</li> <li>• 36. Stress management/emotional control training</li> </ul>	<ul style="list-style-type: none"> <li>• 585 eligible individuals, 301 approached (15% declined)</li> <li>• 47 participants did not complete online survey, N = 164 final sample</li> <li>• 87% retention for 4 week assessment</li> <li>• 80% retention rate at 3 month post quit</li> <li>• 5 intervention participants withdrew</li> <li>• Program overall accepted, text buddy intervention and program likely to be used by 50%, text Crave support used by 30%.</li> </ul>	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](http://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

**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.

**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

(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

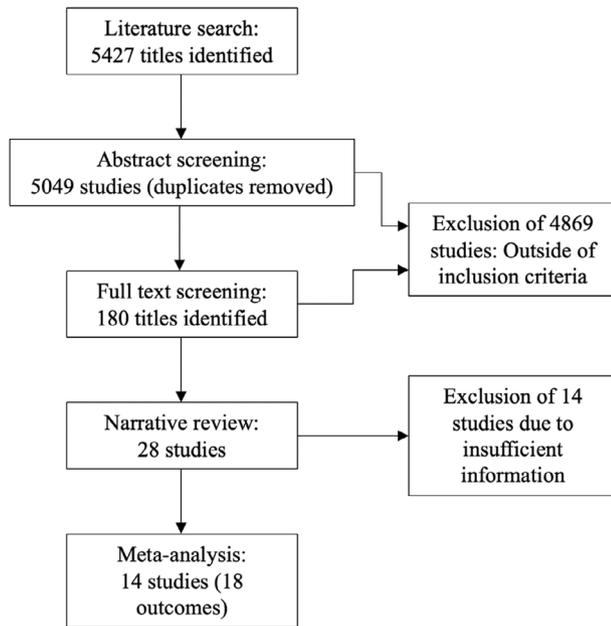
numbers of BCTs are not always associated with better outcomes and Arigo et al. (2020) have pointed out that BCTs may work under some circumstances but not others and thus rely on situational context, indicating that the type of BCT may be more critical than the number. Michie et al. (2009) also point 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.

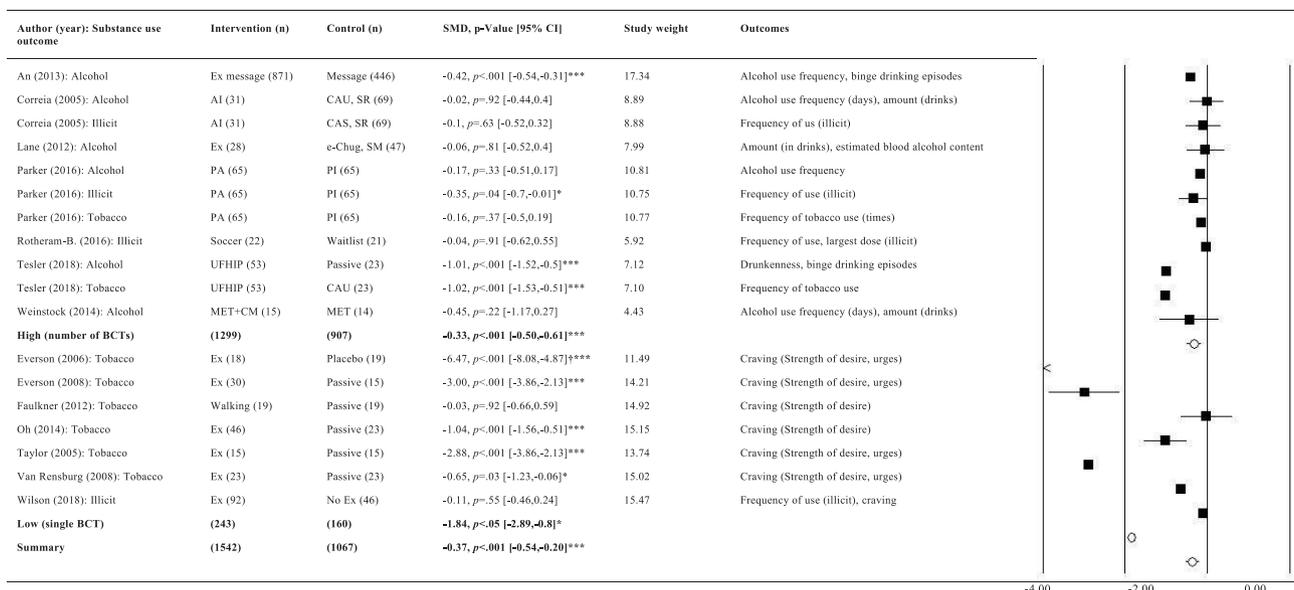
### 4.3 | Strengths and limitations

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



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

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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