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REVIEW ARTICLE

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Physical activity interventions for the promotion of mental health outcomes in at-risk children and adolescents: a systematic review

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ABSTRACT

Many young people are exposed to risk factors that increase their risk of mental illness. Physical activity provision is an increasingly popular approach to protect against mental illness in the face of these risk factors. We examined the effectiveness of physical activity interventions for the promotion of mental health outcomes in at-risk children and adolescents. We searched health databases for randomised and non-randomised intervention studies, with no date restriction, and assessed risk of bias using the Cochrane Risk of Bias tools. We present a narrative synthesis of our results accompanied with a summary of available effect sizes. Thirty-seven reports on 36 studies were included, with multi-sport or yoga interventions the most popular intervention approaches (a combined 50% of included studies). Outcomes measured included internalising, self-evaluative, wellbeing, overall symptomatology, resilience, externalising, and trauma outcomes. We found that 63% of between-groups effects favoured the intervention arm, and 83% of within-groups effects favoured an intervention effect. While recognising high risk of bias, our findings provide evidence in support of the effectiveness of physical activity interventions for promoting mental health outcomes in at-risk young people. We encourage further work designed to better understand the intervention characteristics that may lead to positive benefits.

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Introduction

Mental illness is one of the leading global causes of disease burden (Vigo et al., 2016), with an estimated one billion people worldwide experiencing a mental illness (GBD 2017 Disease and Injury Incidence and Prevalence Collaborators, 2018). The negative impact of mental illness is evident at an individual- (e.g., lower personal income and living standards; Gibb et al., 2010; Kessler et al., 2008),

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relational- (e.g., feelings of isolation; Wang et al., 2017), and societal-level (e.g., economic cost; Doran & Kinchin, 2019). Subsequently, the prevention of mental illness is a key focus of contemporary health promotion research (Fusar-Poli et al., 2021). Childhood and adolescence have been identified as key windows of opportunity for mental illness prevention, given that a substantial proportion of lifetime cases of diagnosed mental illness begin in these periods (Kessler et al., 2005, 2007; Merikangas et al., 2010; Solmi et al., 2022). Additionally, potential intervention benefits extend beyond childhood and adolescence, across the lifespan and intergenerationally (Clark et al., 2020; Patton et al., 2016). In that vein, there is a well-established evidence base showcasing the importance of lifestyle interventions (e.g., physical activity, sleep) in preventing mental illness (see Firth et al., 2020, for a meta-review).

Children may be exposed to a host of individual, environmental, and/or sociocultural risk factors for mental illness (Kieling et al., 2011; Lund et al., 2018). Often, these risk factors are known collectively as adverse childhood experiences (ACEs). Examples of ACEs (see Finkelhor et al., 2013, for a comprehensive outline of adversities) include, but are not limited to: having a parent with a mental illness (Reupert & Maybery, 2016); having a sibling with a chronic health condition or disability (Vermaes et al., 2012); and exposure to domestic violence (Holt et al., 2008). Petruccelli et al. (2019) provided meta-analytic evidence that, typically, the more ACEs one has, the higher the odds ratio associated with a negative outcome (e.g., psychological distress, depressed mood, panic/anxiety). In general, children and adolescents considered to be 'at-risk' of mental health concerns are those who have experienced adversity (including, for example, living in a family with limited socioeconomic resources), disruptive or traumatic life events, or maltreatment (Fryers & Brugha, 2013). Where the aetiology (and, if relevant, ACE) for mental illness is specific, known, and modifiable (e.g., bullying in schools), interventions that directly and systemically target that factor are desirable (i.e., developing an intervention to reduce bullying; Scott et al., 2014). In many cases, though, risk factors may not be specific, known, modifiable, or reliably measurable, and in those cases, researchers have focused more holistically on promoting protective factors that improve mental health outcomes or reduce the incidence of mental illness in at-risk populations (Wille et al., 2008).

Protective factors are mechanisms that may reduce the likelihood of, or protect against, experiencing undesirable outcomes (Shortt & Spence, 2006; Wille et al., 2008). In a seminal article, Rutter (1987) emphasised that a defining feature of protective factors is that they are not merely the opposite of a risk factor but are catalytic in that they interact with risk variables to provide a protective (i.e., buffering) effect. For example, physical activity in and of itself is reported to have protective effects against depression and anxiety (Firth et al., 2020; Fusar-Poli et al., 2021). However, there may also be an opportunity within physical activity interventions to promote protective mechanisms (e.g., physical self-perceptions; see Lubans et al., 2016) to contribute positively to mental health and protect against mental ill health (in addition to the inherent benefits of physical activity).

Researchers and clinicians recognise that at-risk children and adolescents are often a challenging and resistant group (particularly in the context of 'traditional' therapy) and have outlined that approaching interventions of this nature in a more engaging manner may assist in fostering more positive outcomes (Kendall & Peterman, 2015; Sommers-Flanagan & Sommers-Flanagan, 2006). There is an emerging evidence base to show that alternative (i.e., outside of traditional clinical settings) intervention formats may improve mental health outcomes in at-risk children and adolescents. Such approaches include sport-based programmes (Lubans et al., 2012), interventions delivered through online settings (Clarke et al., 2015), animal-assisted programmes (Hoagwood et al., 2017), and art activities (Cohen-Yatziv & Regev, 2019), amongst others. Further investigation of these kinds of 'alternative' approaches is important, with the goal of generating a broader evidence base and more effective early intervention and prevention options for at-risk young people (Herati & Meyer, 2023; Lubans et al., 2012).

The psychological benefits (e.g., well-being, cognitive functioning) of physical activity and sport are well documented (see, for a brief historical account, Biddle & Vergeer, 2019). Additionally, physical activity is relatively (compared to other mental health treatments, e.g., pharmacotherapy) safe, inexpensive, and accessible, making it an attractive option for mental health preventative efforts

(Ekkekakis, 2013). A number of biological, psychosocial, and behavioural mechanisms have been posited to explain the effects of physical activity and sport on mental health – these include the release of neurotransmitters (e.g., dopamine), self-perception, self-esteem, self-efficacy, affect regulation and social support (Craft, 2013; Di Liegro et al., 2019; Kandola et al., 2019; Lubans et al., 2016).

Review evidence for the effectiveness of physical activity interventions on mental health-related outcomes is well established (e.g., Singh et al., 2023) – however, the evidence for at-risk young people is comparatively sparse. In their review on this topic, Lubans et al. (2012) identified that sport and physical activity programmes are potentially effective for improving social and emotional wellbeing in at-risk children and adolescents. However, they identified a lack of high-quality evidence and recommended more rigorous trials be conducted to determine the effectiveness of sport- and physical activity-based programmes more accurately. In other related work, Hermens et al. (2017) synthesised research on sport-related life skills development programmes for vulnerable youth, providing evidence for the potential of sport programmes to have a positive impact on cognitive, emotional, and social life skills. And more recently, Rose and Soundy (2020) conducted a review on physical activity for children and adolescents from low socioeconomic backgrounds (a group of children often considered at-risk due to factors such as limited access to resources or cumulative exposure to stressors; Peverill et al., 2021). Their review corroborated the association between moderate-to-vigorous physical activity and positive mental health and wellbeing outcomes in disadvantaged children and highlighted potential mechanisms of change.

Despite some evidence for the role of sport and physical activity on mental health-related outcomes for at-risk young people, gaps remain in our understanding of this research. In the time since Lubans et al.'s (2012) review (which most closely aligns to the criteria of this review), for example, there has been no update to the review literature to scope more recent work and to identify potential improvements in evidence quality. And, although Hermens et al.'s (2017) review was more recent and did include some (mental health-) relevant emotion-related outcomes (such as global self-worth), their focus was specifically on *life skills* – requiring studies to specifically report (in some capacity) on *life skill development*. This focus potentially excluded important research targeting other mental health and wellbeing indicators. Finally, despite the valuable evidence provided by Rose and Soundy's (2020) even more recent work, their review focused only on one subgroup of the broader 'at-risk' population (i.e., low socioeconomic status children and adolescents).

Developing a greater understanding of the effectiveness of physical activity interventions for young people at risk of mental health issues is critical for refining efforts to improve mental health outcomes in at-risk populations. This is particularly important given that 'at-risk young people' are often targeted as a broad population instead of specific subgroups that fall under the at-risk 'banner'. Our systematic review focus was guided by the lack of up-to-date review evidence for the effectiveness of physical activity interventions on mental health outcomes in at-risk young people. We developed the review with one primary aim: to assess the effectiveness of physical activity interventions for mental health-related outcomes in at-risk young people, in relation to characteristics of the intervention (i.e., the target population, the intervention type, and the 'risk factor' for mental health concerns). With this aim in mind, two research questions guided our review: (1) are physical activity interventions effective in improving mental health outcomes in at-risk young people?; and (2) what characteristics of physical activity interventions for at-risk young people are most likely to lead to positive mental health outcomes?. In addressing these questions, this review will consolidate the literature and provide a foundation for researchers to focus on specific characteristics that may increase the likelihood of successful intervention.

Methods

This review is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Page et al., 2021). The protocol for this systematic review was registered on PROSPERO (CRD42022315464) and is included in Supplementary Material S1. There

were three minor deviations to the protocol. First, we modified our research questions to focus on physical activity broadly, to avoid ambiguity on what constitutes 'sport' or 'physical activity' respectively. We also refocused our research questions to be more specific. In particular, our second research question (see above) was expanded on to include not only information about 'study characteristics', but 'study characteristics which led to positive outcomes'. This was the focus of the research question from the commencement of the review, but our reporting lacked clarity prior to this post-hoc modification. Second, our risk of bias assessment methodology was modified to be more suitable to the review and the interventions we were assessing (i.e., the tool we had selected initially was later deemed to be inappropriate for assessing the risk of bias for individual studies). Finally, graphical reporting of effect sizes and quantitative 'vote counting' procedures were included to complement the narrative synthesis. This approach is suggested by McKenzie and Brennan (2022) where meta-analytic procedures are not possible.

Eligibility criteria

Two reviewers (AS and BK) independently assessed the eligibility of studies according to the inclusion criteria. Studies were included if (a) participants were children or adolescents (mean age under 18 years) at increased risk of mental health issues (for any reason identified by the authors of the original research, and which fits within the broad classification of risk factors for mental health concerns explored above), (b) sport or physical activity was the primary focus of an intervention, and (c) outcomes relating to mental health (protective factors or symptomatology) were measured and reported. We included journal articles, theses, and conference abstracts that fit the above criteria. For clarity, we defined physical activity as a bodily movement that requires energy expenditure (and therefore, interventions which provided opportunities to be physically active were included). Study designs included in this review were randomised controlled trials (RCTs), non-randomised controlled trials (nRCTs), or feasibility or pilot trials. Studies were excluded if (a) participants had an identified previous or existing diagnosis of a mental illness, (b) the intervention was designed for a population other than children or adolescents (e.g., an intervention for mothers, where child mental health was measured), (c) physical activity was not the primary focus of the intervention, or (d) the intervention was designed to improve outcomes not directly related to psychological wellbeing or mental health (e.g., a sport intervention for academic performance in at-risk children). Qualitative studies and book chapters (to maintain search strategy optimisation) were also excluded.

Search strategy

The search strategy is reported in accordance with the PRISMA-S extension for Reporting Literature Searches in Systematic Reviews (Rethlefsen et al., 2021). We conducted a search of six electronic databases in January 2022, namely: MEDLINE, EMBASE, PsycINFO, CINAHL, SPORTDiscus, and Psychological and Behavioural Sciences Collection. MEDLINE, EMBASE and PsycINFO were accessed through Ovid – all other databases were accessed through EBSCOHost. Online databases of grey literature (ProQuest Dissertations and Theses Global, and Web of Science Conference Proceedings Citation Index – Science and Social Science & Humanities) were also searched. The search strategy was developed in consultation with a professional librarian at the lead author's institution – search terms comprising population (e.g., children), intervention (e.g., physical activity) and context (e.g., at-risk) were combined with Medical Subject Headings (MeSH) to form the search strategy (see Supplementary Material S2). In line with recent recommendations (Frandsen et al., 2020; Lefebvre et al., 2022), search terms of outcomes (e.g., mental health) were not included. We did not restrict our search by publication date. Only articles published in English were included. Manual searches of reference lists and article citations (i.e., articles that cited the article of interest) were also conducted. Retrieved articles were deduplicated using methods outlined by Bramer et al. (2016)

prior to abstract screening. An updated search was conducted in February 2023 according to the methods described above.

Study selection and data extraction

Retrieved article information (i.e., titles and abstracts) was imported into EndNote 20, deduplicated, and then transferred into Research Screener (see Chai et al., 2021), a validated semi-automated machine learning tool which ranks and reorders articles based on relevance to the review. Research Screener determines relevance based on 'seed articles' (e.g., examples of relevant studies) provided by the review team, and by machine learning processes based on the reviewers' decisions to include and exclude studies. Sensitivity analyses conducted by Chai et al. (2021) revealed that, using Research Screener, 100% of relevant articles across eleven reviews were identified after screening between 4% and 40% of all articles. Chai et al. (2021) indicate that systematic reviewers can be confident that all relevant articles will have been identified after 50% (which was a conservative estimate) of articles have been screened – we adhered to this recommendation in this review. Two authors (AS and BK) independently evaluated 50% of titles and abstracts for relevance according to the inclusion and exclusion criteria. Disagreements were solved by discussion until consensus, or if necessary, a third reviewer (BJ). The search and selection process are presented in the PRISMA flow diagram in Figure 1.

One reviewer (AS) extracted the following data from selected studies: author, year, location, study design, sample size, participant recruitment, risk factor for mental health issues, participants' age, gender and ethnicity distribution, intervention activity and characteristics (location, duration, dose, provider, adherence, theoretical basis), outcome measures and measurement tools, and results of the study (for relevant outcomes). To ensure the accuracy and reliability of data extraction, a research assistant extracted data from 10% of studies and cross-checked with the first reviewer's data. The agreement percentage between the two reviewers was 92% across the studies. Any queries in data extraction were resolved through discussion with a third reviewer (BK).

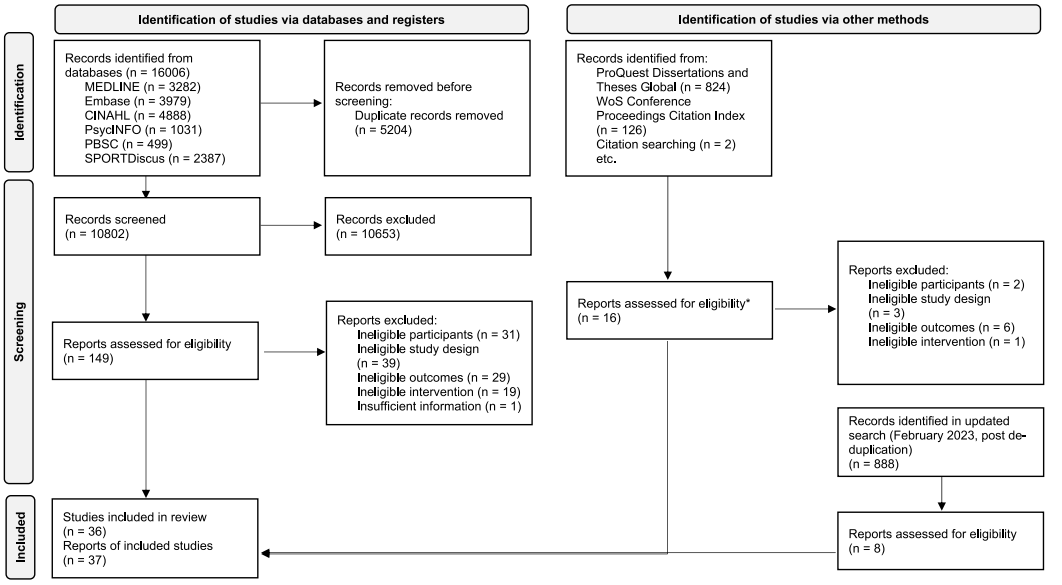

Figure 1. PRISMA flow diagram.

Risk of bias assessment

Due to the broad range of study designs included in the review, three risk of bias assessment tools were utilised – the Cochrane risk of bias tool for randomised trials (RoB 2; Sterne et al., 2019), RoB 2 for cluster-randomised trials (Eldridge et al., 2021) and the Risk of Bias in Non-randomised Studies of Interventions (ROBINS-I; Sterne et al., 2016) tool. One reviewer (AS) conducted all risk of bias assessments, with a second reviewer (BK) completing 11% of the assessments in addition to regular cross-checking to ensure reliability. Across all bias domains for the four assessments that the second reviewer conducted, the agreement percentage was 93%. The RoB 2 tool addresses risk of bias from randomisation, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result, on a three-point scale from *low* to *high* (Sterne et al., 2019). An additional domain is considered in the cluster-randomised trial variant – risk of bias from the timing of identification or recruitment of participants (Eldridge et al., 2021). The ROBINS-I tool assesses the risk of bias due to confounding, selection of participants, classification of interventions, deviations from intended interventions, measurement of outcomes, and selection of reported result, on a four-point scale from *low* to *critical* (Sterne et al., 2016).

Analysis and synthesis

Due to vast differences in interventions, populations, and outcomes, in addition to a lack of compatible data, we deemed it unsuitable to conduct a meta-analysis. Instead, we present our findings according to procedures outlined in the Cochrane Handbook for Systematic Reviews of Interventions (chapter 12; McKenzie & Brennan, 2022). First, we provide descriptive information regarding the included studies. Second (and in line with recommendations to explore data synthesis alternatives beyond a narrative synthesis when meta-analysis is not possible; McKenzie & Brennan, 2022), where appropriate data were available to calculate effect sizes (i.e., means and standard deviations, or other relevant data for use according to Wilson, n.d.), we present a graphical summary of effect estimates. We also present the proportion of effects 'favouring the intervention' (i.e., where the intervention arm had a more favourable score than the control arm for a specific outcome) compared to not favouring an intervention effect (i.e., where the control arm had a more favourable or equal score compared to the intervention arm). The above process, where effects are categorised as favouring the intervention or not, is known as vote counting (McKenzie & Brennan, 2022) – it is important to note that this analysis does not consider statistical significance, but instead the direction of effect. Additionally, each *effect* was included in this process – for example, if a three-armed study included a comparison of an outcome between the intervention arm and each comparator arm, we extracted and reported on both of those comparisons separately. Finally, we present a narrative synthesis of studies according to the type of intervention.

Results

Study characteristics

Our search yielded 37 reports on 36 studies (i.e., two journal articles on the same study were published: Tesler et al., 2018, 2022). For a full summary of study characteristics, see Table 1 below. Half of all studies included in the review were conducted in the USA, and 56% of studies included a control arm (70% of which had an element of randomisation). Of the studies with a control arm, 40% had an active control (and therefore 22% of all studies included in the review had an active control arm). Participant age varied across studies, ranging from 6 to 21-years old (Hilgendorf, 2015; Szoko et al., 2022) – the median number of participants per study included in analyses was 72.5, and across the 36 studies, there were 5,098 participants. The most prevalent risk factor

Table 1. Summary of studies.

Author (year) Location	Risk factor(s)	Sample size (participants analysed only)	Mean age (SD) Age range*	Sport or physical activity Frequency and duration	Outcome(s)	Key findings
Annesi et al. (2008) USA	Ethnic/racial minority Socioeconomic status	Total $N = 269$ Intervention $N = 146$ Control $N = 123$	10.6 (1.1) Not reported	Aerobic and resistance exercise 45 min, 3 days per for 12 weeks Total dose = 27 h	(1) General self-description (2) Physical appearance self-description (3) Physical self-concept (4) Mood (tension) (5) Mood (vigour)	(1) Significantly greater improvements in general self-description (d = .38) in treatment group compared to control group (2) Significantly greater improvements in physical appearance (d = .28) in treatment group compared to control group (3) Significantly greater improvement in physical self-concept (d = .35) scale compared to control group (4) Significantly greater improvements in tension (d = .74) compared to control group (5) Significantly greater improvements in vigour (d = .57) compared to control group
Berger et al. (2009) USA	Ethnic/racial minority Socioeconomic status	Total $N = 71$ Intervention $N = 39$ Control $N = 32$	Intervention = 10.4 (.8); Control = 10.2 (.6) Grade 4 and 5	Yoga 60 min, once per week for 12 weeks Total dose = 12 h	(1) Global self-worth (2) Self-perception	(1) No significant differences between yoga group and non-yoga group at post-intervention on global self-worth (MD = 0.0, $p > .05$) (2) No significant differences between yoga group and non-yoga group at post-intervention on self-perception of physical appearance (MD = 0.0, $p > .05$).
Blowers (2007) USA	Below-median scores on at least four out of following five measures: school connection (i.e., attendance),	Total = 90 Intervention $N = 10$ High-risk comparison $N = 40$ Low-risk comparison $N = 40$	15 Grade 10	Martial arts (Judo) 90 min, 2 days per week for 12 weeks	(1) Self-esteem	Timepoint 2: Within-group improvements in treatment group from baseline (M = 15.85, SD = 3.43) to timepoint 2

(*Continued*)

Table 1. Continued.

Author (year) Location	Risk factor(s)	Sample size (participants analysed only)	Mean age (SD) Age range*	Sport or physical activity Frequency and duration	Outcome(s)	Key findings
	drug use, attitudes toward conflict and violence, grade-point average, and self-esteem			Total dose = 36 h		(M = 17.83, SD = 4.54). High-risk students (M = 17.35, SD = 5.30), low-risk students (M = 21.68, SD = 6.53). Significant differences between high – and low-risk students ($p < .05$, d = .66). Comparisons were made between high-risk and low-risk peers, however between-groups comparison does not differentiate high-risk treatment and high-risk comparison students. Timepoint 3: No significant differences between high-risk (M = 19.17, SD = 5.21) and low-risk (M = 21.90, SD = 5.96) comparison groups ($p = .08$). Self-esteem at timepoint 3 (M = 21.17, SD = 3.65) was presented but no information provided on significant differences between timepoint 3 and timepoint 2 or baseline.
Bonhauser et al. (2005) Chile	Socioeconomic status	Total $N = 198$ Intervention $N = 98$ Control $N = 100$	Intervention = 15.54 (.89); Control = 15.52 (.95) Grade 9	Multi-sport 90 min, 3 days per week for 40 weeks Total dose = 180 h	(1) Anxiety symptoms (2) Depressive symptoms (3) Self-esteem	(1) Post-intervention WMD between intervention and control = −0.94, $p = .000$ (indicating significantly lower anxiety symptoms in intervention) (2) Post-intervention WMD between intervention and control = −0.07, $p = .436$ (indicating no significant differences in depressive symptoms) (3) Post-intervention WMD between intervention and control = 7.17, $p = .000$ (indicating significantly higher self-esteem scores in intervention)

Carter et al. (2017) USA	Ethnic/racial minority Socioeconomic status	Total $N = 111$ Intervention $N = 78$ Control $N = 33$	8.47 (.98) 7–10	Soccer 80 min, 3 days per week for 24 weeks Total dose = 96 h	(1) Internalising symptoms (2) Externalising symptoms	(1) Those in the intervention group showed fewer internalising symptoms at follow-up to controls (beta = −.28, $p < .05$). (2) No significant effect for intervention allocation at follow-up for externalising symptoms (beta = .14, $p > .05$).
Conant et al. (2008) USA	Chronic health condition (epilepsy)	Total $N = 9$	10.6 8–16	Martial arts (Karate) 60 min, once per week for 10 weeks Total dose = 10 h	(1) Self-concept (2) Quality of life	(1) Slight (non-significant) improvement in overall self-concept (MD = 1.26, $p = .92$). No significant differences in any subscale. (2) Non-significant improvement in overall quality of life (MD = 8.83, $p = .31$). Significant differences in memory subscale, but none other.
Crews et al. (2004) Not specified (presumed USA)	Ethnic/racial minority Socioeconomic status	Total $N = 66$ Intervention $N = 34$ Control $N = 32$	Not reported Grade 4	Aerobic exercise 20 min, 3 days per week for 6 weeks Total dose = 6 h	(1) Trait anxiety (2) Depression (3) Self-esteem	(1) No significant between-group differences at post-test ($F = .40$ or .53 [unclear reporting], $p > .05$) (2) Significant between-group differences at post-test ($F = 6.93$, $p < .05$) (3) No significant main effect for time, or interaction effect between group and time ($F = 2.11$, $p > .05$). Significant main effect for group ($F = 9.35$, $p < .01$), indicating that group allocation had a significant effect on self-esteem scores.
Culver et al. (2015) Haiti	Living in an orphanage (and associated trauma)	Total $N = 62$; Yoga intervention $N = 26$; Aerobic dance control $N = 23$; Wait-list control $N = 13$	11.10 (2.12) 7–16	Yoga 45 min, 2 days per week for 8 weeks Total dose = 12 h	(1) Trauma-related symptoms (2) Psychological difficulties	(1) Significant difference between yoga and wait-list control in change in trauma-related symptoms (post-test-pretest) (MD = −8.24, $p = .047$). No significant difference between yoga and dance control.

(*Continued*)

Table 1. Continued.

Author (year) Location	Risk factor(s)	Sample size (participants analysed only)	Mean age (SD) Age range*	Sport or physical activity Frequency and duration	Outcome(s)	Key findings
						(2) No significant differences in change in total difficulties between yoga and wait-list control ($p = .947$), or yoga and dance control.
Dandan (2019) USA	Socioeconomic status, Ethnic/ racial minority	Total $N = 138$; Intervention $N = 80$; Control $N = 58$	12.18 10–17	Multi-sport 90 min, 3 days per week for 10 weeks Total dose = 45 h	(1) Internalising features	(1) Participants in the intervention group demonstrated a greater decrease in internalising symptomology ($B = -.163$, $p = .027$). Variance explained by the model was 28.7% (R^2 = .31, F (4,133) = 14.782, $p < .000$)
de Matos et al. (2017) Portugal	Living in temporary or permanent residential care	Total $N = 32$	13 (1.7) 10–16	Surfing 240 min, 2 days per week for 4 weeks Total dose = 32 h	(1) Psychological difficulties ('Total of difficulties')	(1) Significant decrease in carer-rated total difficulties from baseline to post-intervention (t [27] = 2.67, $p < .05$). No significant differences between baseline and post-intervention on self-reported total difficulties (t = 1.68, $p > .05$)
Draper et al. (2020) UK	Unaccompanied asylum seeker children	Total $N = 20$	Not reported 16–18	Aerobic exercise 120 min, 9 days over a 5-week period Total dose = 18 h	(1) Validity of cognition (2) Subjective units of disturbance	(1) increased VOC at post-treatment (t[20-1] = 3.78, $p = .000638$). Not stated, but assumed just after first session. (2) decreased SUD at post-treatment (t[20-1] = −5.05, $p = .0000036$). Not stated, but assumed just after first session.
Eather et al. (2016) Australia	At risk of psychological distress, determined by score > 15 on the SDQ	For the entire study: Total $N = 96$ Intervention $N = 51$ Control $N = 45$ For the relevant sub-group included for this review: Total $N = 25$ Intervention $N = 8$ Control $N = 17$	15.4 (.51) 15–16	Aerobic and resistance exercise 60 min, 2 days per week for 8 weeks Total dose = 16 h	(1) Total psychological difficulties (2) Global self-esteem	(1) Medium non-significant group x time interaction effect, adjusted MD = -3.32, $p = .199$, d = 0.70. (2) Large significant group x time interaction effect, adjusted MD = 0.72, $p = .01$, d = 1.35

Fishbein et al. (2016) Not specified (presumed USA)	Not succeeding in traditional schools	Total $N = 85$ Intervention $N = 45$ Control $N = 40$	16.7 14–20	Yoga 50 min, 3 days per week for 7 weeks Total dose = 17.5 h	(1) Emotional dysregulation (2) Coping (3) Mood (4) Externalising and social competency behaviours	Group by time interactions not statistically significant for any of the relevant outcomes for this review. Authors do not present any numerical evidence.
Frank et al. (2014) USA	Not succeeding in traditional schools	Total $N = 49$	Not reported Grade 9–12	Yoga 30 min, 3–4 days per week for 12 weeks Total dose = 18 h (for 3 sessions per week)	(1) Positive affect (2) Negative affect (3) Depression (4) Anxiety (5) Somatisation (6) Emotional distress (Global Severity Index) (7) Stress symptomatology	(1) No significant pre-post differences in positive affect ($t = 0.71$, $p = 0.48$) (2) No significant pre-post differences in negative affect ($t = -1.56$, $p = .13$) (3) Significant pre-post reductions in depression ($t = -3.29$, $p = .01$, $d = .32$) (4) Significant pre-post reductions on anxiety ($t = -3.51$, $p = .01$, $d = .23$) (5) No significant pre-post differences in somatisation ($t = -1.49$, $p = .14$). (6) Significant pre-post reductions in global severity index (i.e., emotional distress; $t = -2.69$, $p = .01$, $d = .40$). (7) All subscales comprising the stress symptomatology measure were significantly lower at follow-up compared to baseline.
Gehricke et al. (2022) USA	ASD diagnosis, low socioeconomic status	Total $N = 117$; PA intervention $N = 53$; Comparison $N = 64$	Intervention = 9.3 (2.0); Comparator = 9.7 (2.2) 6–12	Aerobic and resistance exercise 50 min, (up to) 3 days per week for 8 weeks Total dose = 20 h	(1) Anxiety	(1) Significant within-group improvement in anxiety measured by both the CBCL (MD = −5.59, $p < .001$) and SCARED (MD = −6.49, $p < .001$). However, no treatment effect (i.e., exercise vs comparator) observed for change in anxiety scores for either measurement (CBCL, MD = -2.16, $p = .150$; SCARED, MD = 3.22, $p = .188$).
Godfrey et al. (2015) UK	Vulnerable, due to: social isolation, anxiety or sensory issues	Total $N = 84$	Not reported. However, 33% of participants	Surfing Session length not	(1) Positive functioning/ outlook	(1) Significant improvement in positive functioning (t[82] = −6.42, $p < .000$)

(*Continued*)

Table 1. Continued.

Author (year) Location	Risk factor(s)	Sample size (participants analysed only)	Mean age (SD) Age range*	Sport or physical activity Frequency and duration	Outcome(s)	Key findings
			between age 8–9, and 54% between 10 and 14. 8–18	reported, 1 day per week for 6 weeks	(2) Self-esteem (3) Emotional wellbeing	(2) Significant improvement in Self-esteem (t[81] = –3.87, p < .000) (3) Significant improvement in emotional wellbeing (t[81] = –5.91, p < .000).
Harwood-Gross et al. (2021) Israel	At-risk of not completing 'normative school' education	Total N = 39 Intervention N = 20 Control N = 19	15.6 (.81) 14–17.7	Martial arts (mix of Karate, Judo, Jujitsu) 50 min, two days per week for 26 weeks Total dose = 43.33 h	(1) Self-esteem (2) Aggression	(1) No significant differences between the intervention and control group on self-esteem (t = .47, p = .64) (2) No significant differences between the intervention and control group on aggression (t = .20, p = .85).
Hignett et al. (2018) UK	Exclusion from mainstream schools, or at-risk of exclusion	Total N = 58 (N = 45 at follow-up)	14.25 13–16	Surfing Session length not reported, once per week for 12 weeks	(1) Well-being	(1) Satisfaction with life overall did not significantly differ from T1 to T2 (MD = .18; p > .225).
Hilgendorf (2015) USA	History of chronic maltreatment/trauma (unclear, but appears to be only participants living in long-term residential care)	Total N = 34	Not reported 6–16	Multi-sport 60 min, 3 days per week for 8 weeks Total dose = 24 h	(1) Psychological difficulties (note: authors refer to measure of 'behaviour' but do not specify the subscale (s) used for this measure, or provide mean scores)	(1) No significant differences between baseline and follow-up on 'behaviours' (MD = −.733, p = .650)
Kishton and Dixon (1995) USA	Socioeconomic status Ethnic/racial minority	Total N = 74	10.9 10–16	Multi-sport 300–360 min, every day for 25 days (camp) Total dose = 125 h (for 300 min per day)	(1) Global self-worth	(1) Girls' scores on global self-worth subscale significantly decreased (t[31] = 2.78, p < .01). Boys scores did not significantly differ between pre-and post-intervention
Kwasky and Serowoky (2018) USA	Urban environment, higher risk of exposure to violence and trauma, potential adverse childhood experiences	Total N = 14 (possibly 15, unclear if dropout was included in analyses)	12.21 (1.47) 11–14	Yoga Session length not reported, 2 days per week for 8 weeks	(1) Emotional self-efficacy	(1) No significant improvements in emotional self-efficacy (X^2 [2] = .051, p = .975). Mean scores (SD) at T0, T1, T2: 29.10 (5.93), 29.60 (5.52), 30.30 (5.81).
Laberge et al. (2012) Canada	Socioeconomic status	Total N = 222 Intervention N = 131 Control N = 91	Intervention = 13.8 (.7); Control = 12.5 (.6) 11–16	Multi-sport 45 min, 3–5 days per week for 16 weeks Total dose = 36 h (for 3 days per week)	(1) Self-esteem	(1) No significant interaction effect between group x time (F [1,212] = 1.06, p = 0.304). Intervention group MD = 0.6 (boys) and 0.7 (girls).

Lemstra and Rogers (2022) Canada	Obesity	Total $N = 2292$	Not reported 11–17	Aerobic exercise 60 min, 5 days per week for 12 weeks Total dose = 60 h	(1) Depressed mood (depressive symptoms) (2) Self-esteem	(1) Percentage of participants with depressed mood decreased 18.4% (d = .94) following programme participation (using other scale, those with severe depressed mood decreased 46.1%). (2) effect of intervention on self-esteem not reported – only self-esteem data reported is associations between individual item scores and depressed mood
Mendelson et al. (2010) USA	Urban environment (predominantly, Ethnic/racial minority, socioeconomic status and exposure to violence)	Total $N = 97$ Intervention $N = 51$ Control $N = 46$ (note 5 participants were removed from analyses due to not completing the study, however authors do not report which group they were in; however, the sample size for each group at follow-up was 42–47 and 40–43 respectively)	Fourth graders = 9.7 (.7); Fifth graders = 10.6 (.7) Grade 4 and 5	Yoga 45 min, 4 days per week for 12 weeks Total dose = 36 h	(1) Involuntary stress responses (involuntary engagement; coping) (2) Depressive symptoms (3) Positive affect (4) Negative affect	(1) Significantly lower (more desirable) scores on involuntary engagement in intervention group at post-intervention compared to controls (adjusted MD = .26, $p < .0001$). (2) No significant differences between intervention and control groups at post-intervention in depressive symptoms (adjusted MD = .55, $p > .05$) (3) No significant differences between intervention and control groups at post-intervention in positive affect (adjusted MD = .3, $p > .05$) (4) No significant differences between intervention and control groups at post-intervention in negative affect (adjusted MD = .21, $p > .05$)
Momartin et al. (2019) Australia	Refugees who have resettled in a new country	Total $N = 32$	15 12–18	Martial Arts (Capoeira Angola) 60 min, 1 d per week for 36 weeks (estimated) Total dose = 36 h	(1) Psychological difficulties	(1) Significant reductions in total difficulties score from pre – to post-intervention (MD = 2.6, t [31] = 3.88, $p = .001$).
Pereira et al. (2020) Portugal	Living in a residential care institution	Total $N = 60$ Intervention $N = 28$ Control $N = 32$	13.83 (2.6) 7–17	Surfing 180 min, once per week for 21 weeks Total dose = 63 h	(1) Psychological difficulties (2) Anxiety symptoms (3) Depressive symptoms (4) Self-esteem	(1) No significant interaction effect between time and condition on self-reported psychological difficulties (F

(*Continued*)

Table 1. Continued.

Author (year) Location	Risk factor(s)	Sample size (participants analysed only)	Mean age (SD) Age range*	Sport or physical activity Frequency and duration	Outcome(s)	Key findings
						[1,57] = .00, $p > .05$, $d = .01$). Significant condition × time interaction effect on carer-reported psychological difficulties (F[1,57] = 6.11, $p < .05$, d = −.62). (2) No significant interaction effect between time and condition on anxiety symptoms (F[1,57] = .76, $p > .05$, d = .26), (3) No significant interaction effect between time and condition on depressive symptoms (F[1,57] = 1.13, $p > .05$, d = .23), (4) No significant interaction effect between time and condition on self-esteem (F [1,57] = .25, $p > .05$, d = -.09).
Richards et al. (2014) Uganda	Post-conflict setting, low socioeconomic status,	(Included in analysis for mental health outcomes) Total $N = 1454$ Intervention $N = 155$ Wait-list control $N = 71$ (boys only) Observational group $N = 1228$	Not reported 11–14	Soccer Approximately 130 min, once per week for 9 weeks Total dose = 19.5 h	(1) Depression-like syndrome (symptoms) (2) Anxiety-like syndrome (symptoms)	(1) Within-group DLS scores significantly improved between baseline and follow-up for wait-list and non-registered boys, but not for intervention boys. Only non-registered girls experienced a significant improvement in scores. There were significant differences in mean change between the intervention and wait-list group (ES = .67, $p < .05$) and intervention and non-registered group (ES = .25, $p < .05$) boys, indicating that DLS scores of boys in the intervention group significantly worsened compared to others. No significant between-groups changes as per ANOVA analysis for girls.

						(2) Within-group ALS scores significantly improved between baseline and follow-up for wait-list and non-registered boys, but not for intervention boys. Only non-registered girls experienced a significant improvement in scores. There were significant differences in mean change between the intervention and wait-list group (ES = .63, $p < .05$) and intervention and non-registered group (ES = .26, $p < .05$) boys, indicating that ALS scores of boys in the intervention group significantly worsened compared to others. No significant between-groups changes as per ANOVA analysis for girls.
Sarkissian et al. (2018) USA	Socioeconomic status Ethnic/racial minority	Total $N = 30$	Not reported 9–14	Yoga 50 min, once per week for 10 weeks (note: one third of participants attended sessions twice per week) Total dose = 11 h (averaged out between the two thirds of participants who attended 8.33 h, and the one third of participants who attended 16.67 h)	(1) Stress (2) Positive affect (3) Negative affect (4) Resilience	(1) Significant decrease in stress from pre – to post-intervention ($t[30] = 2.38$, $p < .05$, $d = .42$), (2) Significant increase in positive affect ($t[30] = 2.62$, $p < .05$, $d = .41$) (3) No significant differences between pre – and post-intervention on negative affect ($t[30] = 0.75$, $p > .05$). (4) Significant increase in resilience ($t[30] = 3.58$, $p < .001$, $d = .53$).
Szoko et al. (2022) USA	Involved in juvenile court	Total $N = 16$	16.2 (1.4) 11–21	Yoga 60 min, once per week. Number of sessions/ weeks not reported	(1) Resilience (2) Psychological distress	(1) No significant pre-post intervention change in resilience (2) No significant pre-post intervention change in psychological distress

(*Continued*)

Table 1. Continued.

Author (year) Location	Risk factor(s)	Sample size (participants analysed only)	Mean age (SD) Age range*	Sport or physical activity Frequency and duration	Outcome(s)	Key findings
Tesler et al. (2022) Israel Tesler et al. (2018) Israel	Exclusion from mainstream school	Total $N = 76$ Intervention $N = 53$ Control $N = 23$	16.86 (.85) 15–18	Multi-sport 60 min (estimated), 3 days per week for 43 weeks (estimated) Total dose = 129 h (estimated)	(1) Self-efficacy (2) Life satisfaction	(1) Significant group by time differences found for self-efficacy, $F(1,73) = 5.21$, $p = .025$, partial eta^2 = .067. (2) Significant group by time differences found for life satisfaction, $F(1,73) = 8.98$, $p = .004$, partial eta^2 = .114. (2) (2018 study) Significant between-groups differences in life satisfaction from T1 to T2 (difference in mean change = 1.71, $p = .013$)
Tester et al. (1999) Singapore	Identified as 'at-risk' due to low self-perceptions	Total $N = 991$ Primary school cohort $N = 445$ Secondary school cohort $N = 546$	Not reported 6–16	Basketball Not reported	(1) Self-esteem	(1) 44% increase in overall self-esteem following primary school students' participation in the programme. 18% increase in overall self-esteem for secondary school students.
Tilzey (2020) USA	Newcomer immigrant adolescent girls	Total $N = 20$ (note: a comparator of data from 52 individuals was used to compare internalising and externalising data from the present sample to matched population means)	16.75 (1.21) 15–19	Soccer Not reported	(1) Internalising symptoms (2) Externalising symptoms (3) Coping strategies	(1) No statistically significant differences between newcomer immigrant girls who participate in the programme and those who do not on internalising symptoms ($t[19] = 2.622$, $p = .017$). Note that $p < .05$, and therefore either the result was statistically significant, or there was an error in reporting the p value. (2) No statistically significant differences between newcomer immigrant girls who participate in the programme and those who do not on externalising symptoms ($t[17] = 1.835$, $p = .084$).

						(3) 3 out of the 5 most common coping strategies by participants in the SWB programme were approach-oriented (the other two were escape-oriented). Participants rated approach-oriented strategies as more efficacious.
Ullrich-French et al. (2012) USA	Socioeconomic status	Total *N* = 197	11.8 (1.6) 9–16	Multi-sport 360 min, 5 days per week for 4 weeks Total dose = 120 h	(1) Global self-worth (2) Physical self-worth (3) Hope	(1) Significant improvements in global self-worth between Time 1 and Time 2, $F = 17.12$, partial n^2 = .15, $p < .01$ (2) Significant improvements in physical self-worth between Time 1 and Time 2, $F = 11.12$, partial n^2 = .05, $p < .01$ (3) No significant differences observed for hope, F = .74.
Velásquez et al. (2015) Colombia	Socioeconomic status	Total *N* = 125 Intervention *N* = 68 Control *N* = 57	Not reported Grade 5–9	Yoga 120 min, for 24 sessions (assumed weekly) Total dose = 48 h	(1) Anxiety (2) Depression (3) Aggression	(1) Significant interaction effect for anxiety (F[1,123] = 4.03, $p < .05$). Paired comparisons of pre – and post-test scores showed a significant decrease in anxiety (F[1,123] = 3.87, $p < .05$, d = .21). (2) Significant interaction effect for depression (F[1,123] = 9.52, $p < .05$). However, ANCOVA analysis revealed no significant main effect on depression. (3) No interaction effect for aggression. Mean change in control = -.04, mean change in experimental group = -.03 (max score = 1).
Welfare and Mitchell (2005) UK	Juvenile detention	Total *N* = 16	Not reported 15–18	Multi-sport 120 min, for 12 sessions (assumed weekly) Total dose = 24 h	(1) Hopelessness (2) Self-esteem	(1) Decrease in mean hopelessness score from 7 (time 1) to 4 (time 2), and maintenance at 4 at time 3. (2) Increase in mean self-esteem score from 17 (time 1) to 18 (time 2) to 19 (time 3).

(*Continued*)

Table 1. Continued.

Author (year) Location	Risk factor(s)	Sample size (participants analysed only)	Mean age (SD) Age range*	Sport or physical activity Frequency and duration	Outcome(s)	Key findings
Xu et al. (2021) China	Identified as either 'vulnerable', 'symptomatic but contented', or 'distressed' according to measures of psychological distress and subjective well-being	Total $N = 83$ (selected from 1018 adolescents) Intervention $N = 39$ Control $N = 44$	Not reported for final sample, however from original sample the participants were drawn from = 13.99 (.49) 12–19 or 13–19 (conflicting reporting in article)	Multi-sport 40–60 min, 3 days per week for 8 weeks Total dose = 16 h (for 40 min per session)	(1) Psychological distress (2) Well-being (3) Positive emotions (4) Positive psychological functioning	Between-groups (intervention vs control) differences reported for each subgroup (vulnerable, symptomatic but contented, distressed): (1) Significant differences at follow-up between intervention and control within the vulnerable ($t = -3.85$, $p < .05$), symptomatic but contented ($t = -4.77$, $p < .05$), and distressed ($t = -4.08$, $p < .05$) subgroups. (2) Significant differences at follow-up between intervention and control within the vulnerable ($t = 3.88$, $p < .05$), symptomatic but contented ($t = 3.62$, $p < .05$), and distressed ($t = 3.31$, $p < .05$) subgroups. (3) Significant differences at follow-up between intervention and control within the vulnerable ($t = 3.08$, $p < .05$), symptomatic but contented ($t = 2.33$, $p < .05$), and distressed ($t = 2.94$, $p < .05$) subgroups. (4) Significant differences at follow-up between intervention and control within the vulnerable ($t = 2.90$, $p < .05$), symptomatic but contented ($t = 2.87$, $p < .05$), and distressed ($t = 4.38$, $p < .05$) subgroups.

Note: * = Age range reported as school grade range in some instances. Session length includes all other activity included in intervention (i.e., may not be all physical activity). Total dose describes the maximum exposure to the intervention if a participant attended all sessions.

among included studies was low socioeconomic status. For a visual depiction of participant risk factors, see Figure 2.

Across the 36 studies, 85 outcomes were measured and reported – we categorised these outcomes into seven distinct categories following consultation with an expert in the mental health field, and the literature: (1) Internalising outcomes (measured 36 times; e.g., anxiety symptoms, depressive symptoms, mood), (2) self-evaluative outcomes (22; e.g., self-esteem, self-concept, self-worth), (3) wellbeing outcomes (8; e.g., emotional wellbeing, life satisfaction), (4) overall symptomatology (7; e.g., psychological difficulties, emotional dysregulation), (5) externalising outcomes (5; e.g., externalising symptoms, aggression), (6) resilience/coping outcomes (4; e.g., resilience, coping strategies), and (7) trauma outcomes (3; e.g., validity of cognition, trauma-related symptoms). For a graphical representation of outcome measures, see Figure 3.

For intervention factors, the median intervention dose was 29.5 h. Intervention dose was calculated as the duration of an individual intervention session multiplied by the number of sessions, and included all intervention components (i.e., if an intervention had multiple components, we did not extract only physical activity). Six studies did not report session duration or frequency and were therefore not included in the calculation of the median intervention dose. For studies that reported a range for number of sessions or session duration, the lowest value was used for calculation of intervention dose. All interventions were delivered in a group setting. There were a range of physical activities used to promote mental health outcomes – the most common of which were multi-sport (25%) and yoga (25%) interventions, but physical activities also included aerobic and resistance exercise, surfing, martial arts, basketball, and soccer (see narrative synthesis

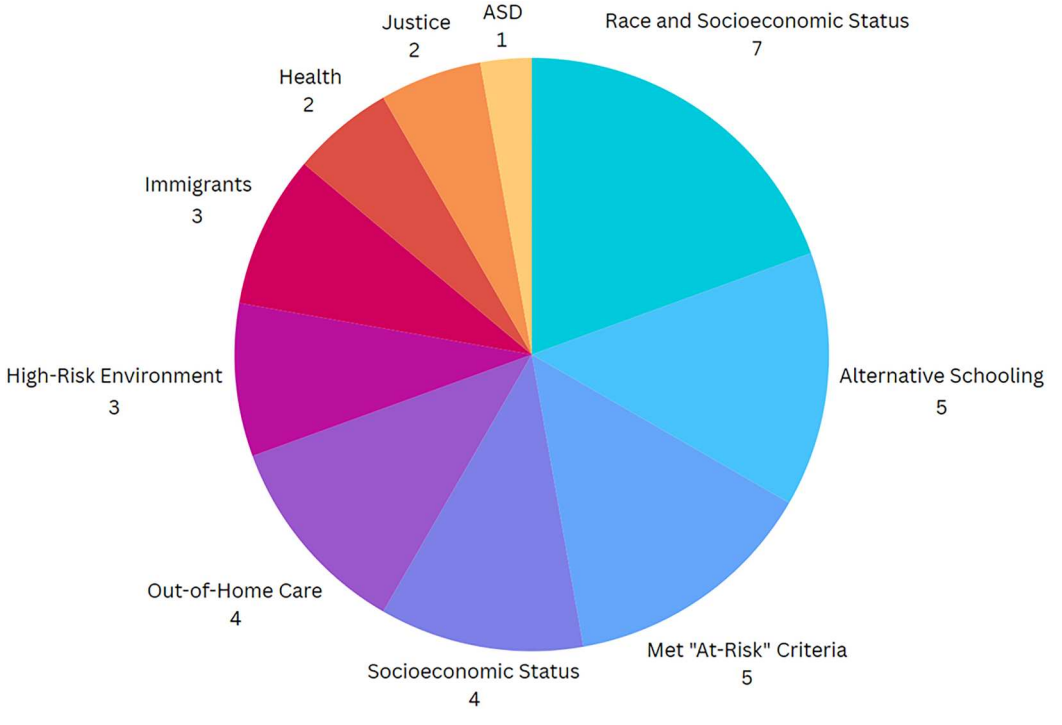

Figure 2. Participant risk factors in included studies.

Note. This figure shows the number of included studies that were targeted at each risk factor (i.e., the 'reasons' that young people participating in each study were deemed to be 'at-risk'). 'Alternative Schooling' = exclusion from mainstream schooling; 'Immigrants' = recent immigrants and refugees; 'Health' = health condition; 'Justice' = involved in the juvenile justice system; 'ASD' = Autism Spectrum Disorder from a low socioeconomic background.

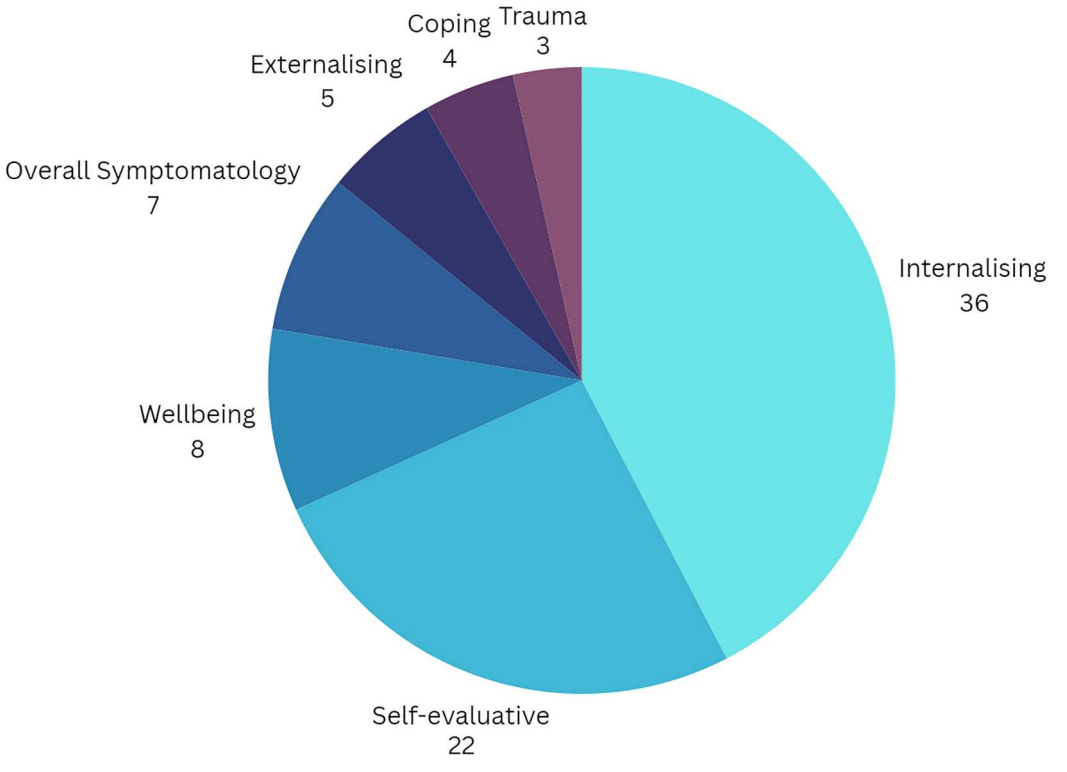

Figure 3. Outcomes measured in included studies.

below). For the interested reader, brief descriptions of each intervention included in this review are presented in Supplementary Material S3.

Risk of bias assessment

Twenty-two studies (twenty-three reports, when including the two articles from the same study) were assessed for risk of bias via the ROBINS-I tool, eight studies via the RoB 2.0 tool, and five studies via the RoB 2.0 Cluster tool. One study was not assessed for risk of bias as it was a conference abstract and would therefore not be expected to provide sufficient information to make judgement on risk of bias domains. The risk of bias tools used in this review are designed to assess risk of bias at an *outcome* level (e.g., if four outcomes were measured in one study, all four outcomes had their own risk of bias assessment, instead of one per study). Figures 4–6 below provide information regarding the risk of bias within each bias domain. Overall, there was a high ('serious' for ROBINS-I) risk of bias across outcomes, and across bias domains. All studies assessed using the ROBINS-I tool were deemed to have a serious risk of bias, primarily due to the *outcome measurement* domain, which typically considers self-report psychological measures as having a high risk of bias. To account for this, we also provide an *overall adjusted* domain (see Figure 4), which removes the outcome measurement domain from consideration. Although this procedure improved (i.e., reduced) the risk of bias assessment for some outcomes (from serious to moderate), more than 60% of outcomes remained in the serious risk category. A moderate-to-high risk of bias was present across all study characteristics (e.g., intervention type, outcome, risk factor) irrespective of the risk of bias assessment tool used, and there were no patterns in regard to specific characteristics among included studies in the review.

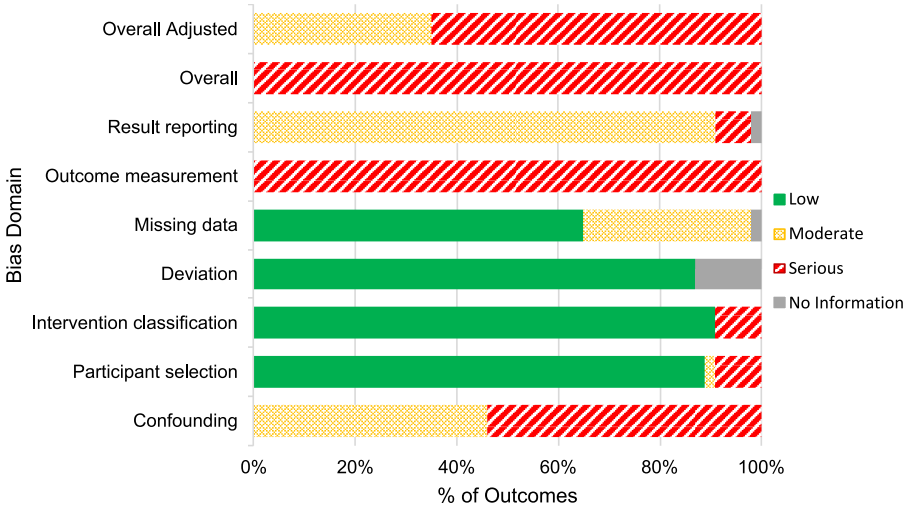

Figure 4. ROBINS-I assessments.

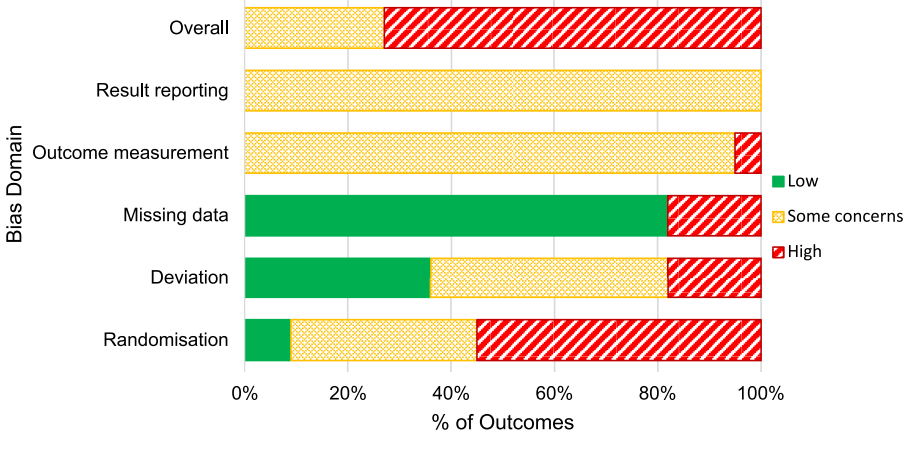

Figure 5. Rob 2.0 assessments.

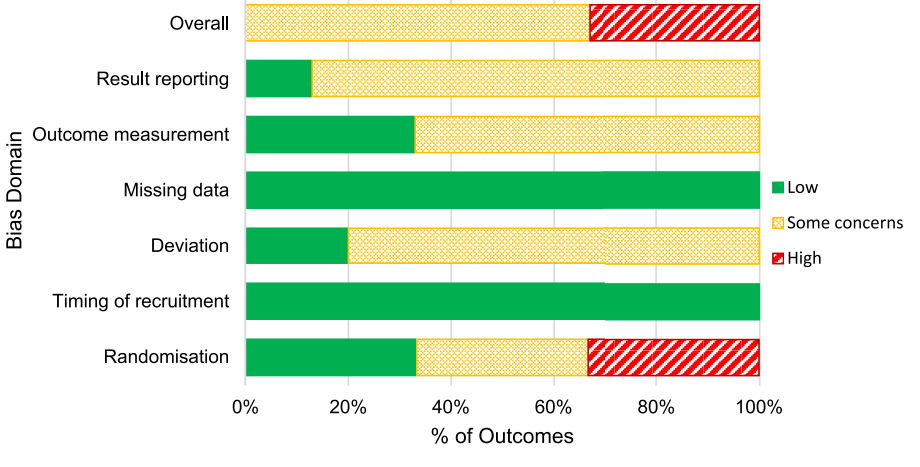

Figure 6. ROB cluster assessments.

Study findings

There was evidence indicating an effect of physical activity interventions on mental health-related outcomes (i.e., on the 'categories' of outcomes listed above; see Figure 3): of the between-groups (i.e., intervention against comparator / control arm) effects where the direction of effect could be ascertained, 39 favoured the intervention arm (62.9%), 10 favoured the control arm (16.1%), and three favoured neither arm (i.e., outcome scores were identical between-groups). For 10 effects, there was insufficient information to confidently identify the direction of effect (and therefore, the proportion of effects favouring the intervention from studies with available information was 75%, and 19% for effects favouring the control). A graphical presentation of the range of between-group effect sizes for characteristics with sufficient available data (i.e., a minimum of five effect sizes) is provided in Figure 7 (with shape indicating risk of bias for each effect). The median effect size (of 20 effects from eight studies) for internalising symptoms was $d = 0.38$, and the median

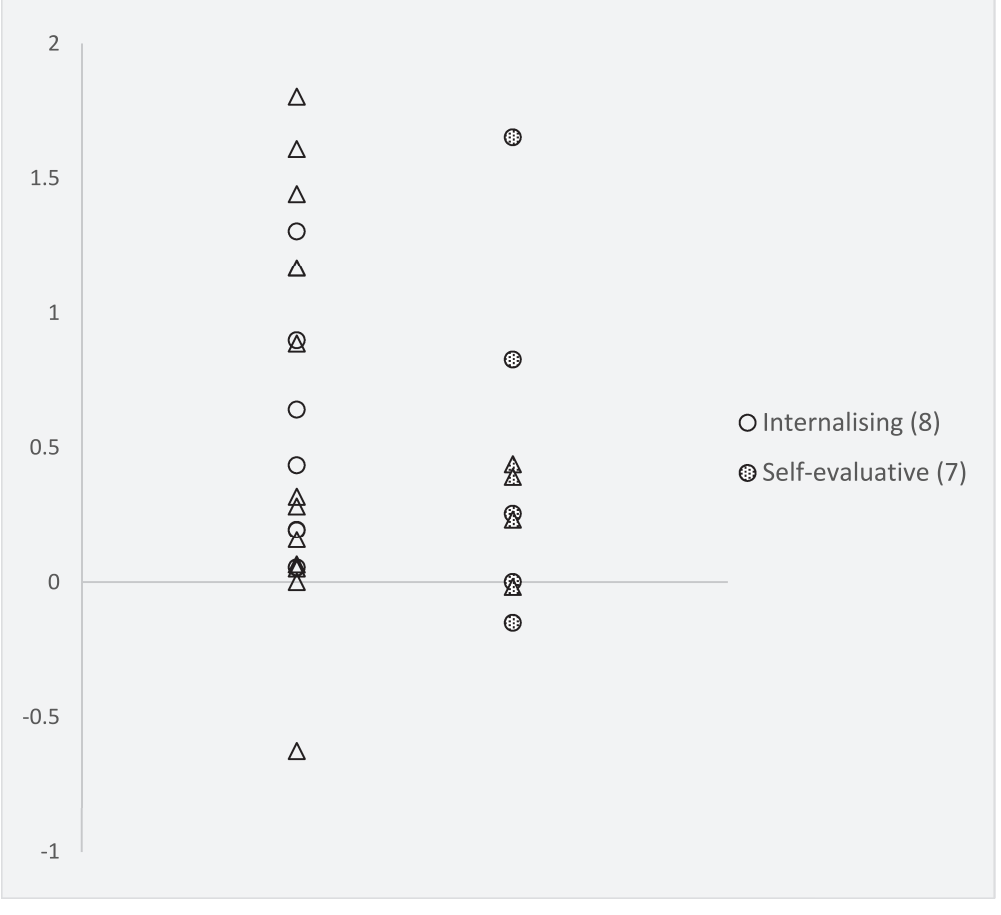

Figure 7. Summary of effect sizes in controlled studies by outcome.

Note: An effect size above zero indicates a positive intervention effect. Due to the variance in outcomes measured within included studies, and the differences in measurement approach within an outcome category, we converted all 'desirable' effects to a positive effect size, and 'undesirable' effects to a negative effect size. For example, some outcomes or measures within the internalising category 'improve' when one's score increases (e.g., affect), whereas other outcomes are measured such that a decrease in one's score is indicative of an improvement (e.g., depressive symptoms). Subsequently, across all outcomes, all effect sizes are in the same direction (and therefore a negative effect size is a negative, or 'undesirable' finding). The number in parentheses of the legend indicates the number of studies effect size data were extracted from for that outcome. The shape of the data point indicates the risk of bias – triangular data points indicate a high risk of bias, and circular data points indicate a moderate risk of bias. For effects assessed for risk of bias using the ROBINS-I tool, the 'overall adjusted' risk of bias assessment was used.

Table 2. Direction of effects grouped by intervention type, risk factor, and outcome.

	Between-groups effects			Within-groups effects			
	+	-	Nil	+	-	Nil	No Data
Intervention Type							
Multi-Sport	18	0	0	5	1	0	1
Yoga	6	4	3	11	1	0	6
Aerobic / Resistance Exercise	10	2	0	3	0	0	1
Surfing	3	1	0	6	0	0	0
Martial Arts	1	1	0	3	0	0	1
Soccer	1	2	0	0	0	0	4
Basketball	0	0	0	0	0	0	1
Risk Factor							
Race & Socioeconomic Status	8	1	2	3	2	0	2
Alternative Education Pathways	3	1	0	8	0	0	4
Criteria-Based Assessment	14	0	0	3	0	0	2
Socioeconomic Status	5	1	1	3	0	0	0
Out-of-Home Care	4	4	0	3	0	0	0
High-Risk Environment	4	0	0	1	0	0	2
Immigrant or Refugee	0	2	0	3	0	0	1
Physical Health Condition	0	0	0	3	0	0	1
Juvenile Justice System	0	0	0	2	0	0	2
ASD & Socioeconomic Status	1	1	0	0	0	0	0
Outcome Classification							
Internalising	21	2	1	11	1	0	5
Self-Evaluative	8	2	1	6	1	0	4
Wellbeing	7	0	0	5	0	0	0
Overall Symptomatology	2	2	0	4	0	0	1
Externalising	1	2	0	0	0	0	2
Resilience / Coping	0	0	0	1	0	0	3
Trauma	0	2	0	2	0	0	0

Note: Vote counting does not take statistical significance into account; the above table refers to the number of effects which were in a 'positive' (i.e., desirable; in the '+' column) direction, the number of effects which were in a negative (i.e., undesirable; in the '-' column) direction, and the number of effects which were neither in a positive or negative direction. 'No data' refers to outcomes where there were insufficient data to calculate effect sizes (or, where data were unclear), and were therefore not included in vote counting analyses. 'ASD' refers to Autism Spectrum Disorder.

effect size (of ten effects from seven studies) for self-evaluative outcomes was $d = 0.25$. Additionally, 29 (out of 35; 82.9%) within-groups effects (i.e., findings derived from pre-to-post change in single-group, uncontrolled studies) displayed evidence of a *potential* intervention effect, where scores on the outcome were more favourable at follow-up compared to baseline. It is important to exercise caution, however, when considering these within-group effects due to the absence of control measures.

In addition to overall effectiveness of physical activity interventions on mental health-related outcomes in at-risk young people, we explored the direction of effects organised by intervention type, risk factor, and outcome classification. A summary of these findings is available in Table 2. Only one study (out of nine) involving a multi-sport intervention reported an effect which did not favour the intervention – 23 effects (from seven studies) favoured the intervention, and one study had insufficient data. For yoga interventions, evidence was mixed – of 17 between-groups effects (from five studies), only six effects favoured the intervention. In regard to risk factor, 11 out of 18 effects for interventions for people deemed to be of a 'high-risk' race and socioeconomic status favoured the intervention. Notably, half of the between-groups effects for interventions for children in out-of-home care favoured the control. Analysis of direction of effect by outcome revealed that the majority (32 out of 41) of effects for internalising outcomes favoured the intervention (from 18 studies, of which three reported an effect favouring the control). A slightly lower proportion of effects for self-evaluative outcomes favoured the intervention (14 out of 22 effects, from 18 studies). Additionally, all six studies investigating wellbeing outcomes revealed positive intervention effects.

Narrative synthesis

The findings summary above is an amalgamation of results according to the direction of effect. The following narrative synthesis, however, provides an overview of findings from included studies according to how they are reported in the study (i.e., generally, with reference to statistical significance), categorised by the 'type' of intervention. The purpose of this synthesis is to provide an overall depiction of the landscape of the literature – for specific details about each study (and characteristics of each intervention), we refer the reader to Table 1 and Supplementary Material S3.

Multi-sport interventions

The most common approach (alongside yoga; 25% of included studies) to intervention was categorised as a 'multi-sport' intervention. These studies all used multiple sports or physical activities within their intervention or provided a choice of activity for participants. Five studies involved interventions for children or adolescents in low socioeconomic situations (Bonhauser et al., 2005; Dandan, 2019; Kishton & Dixon, 1995; Laberge et al., 2012; Ullrich-French et al., 2012). Across these five studies, evidence is mixed in regard to the effectiveness of multi-sport interventions for at-risk young people – three studies reported a positive intervention effect for at least one of their outcomes, and two studies found no intervention effect. Within these studies, positive intervention effects were found for two internalising outcomes: Bonhauser et al. (2005) reported that, following a multi-sport intervention for adolescents in Chile, those who participated in the intervention demonstrated significantly lower anxiety symptoms, and Dandan (2019) reported substantial improvements in internalising features following a team-work based multi-sport intervention. Additionally, two significant positive findings were reported for self-evaluative outcomes: in Ullrich-French et al.'s (2012) study, children's global and physical self-worth improved following a summer camp intervention, and Bonhauser et al. (2005) found that intervention participants presented with higher self-esteem scores compared to controls following their intervention.

However, the above studies also reported some findings which did not support the effectiveness of multi-sport interventions for mental health outcomes in young people with low socioeconomic status – namely, no significant intervention effect was found for depressive symptoms (Bonhauser et al., 2005) or hope (Ullrich-French et al., 2012). Similarly, Laberge et al. (2012) found no significant interaction effect (group-by-time) on self-esteem following an in-school, lunch-time intervention. Of particular note is the work by Kishton and Dixon (1995) – following a summer sports camp, boys' pre – and post-intervention global self-worth scores were not significantly different, however, girls' self-worth significantly *decreased*, representing a negative finding for the effect of the multi-sport intervention.

Four other multi-sport interventions were included in the review targeting different populations (Hilgendorf, 2015; Tesler et al., 2018, 2022; Welfare & Mitchell, 2005; Xu et al., 2021). Positive findings were reported by Welfare and Mitchell (2005), who demonstrated improvements in self-esteem and reductions in feelings of hopelessness (although statistical significance was not reported) following a multi-sport intervention for adolescents in juvenile detention. In addition, Tesler et al. (2018, 2022) reported substantially higher self-efficacy and life satisfaction in at-risk youth following a multi-sport intervention, and Xu et al. (2021) found significant between-groups effects favouring the intervention for well-being, psychological distress, positive emotions, and positive psychological functioning. Hilgendorf (2015), however, found no significant differences in psychological difficulties between baseline and follow-up in children with a history of chronic maltreatment. Many multi-sport interventions incorporated a classroom learning / discussion element to complement the physical activity component (Dandan, 2019; Kishton & Dixon, 1995; Tesler et al., 2018, 2022; Ullrich-French et al., 2012; Welfare & Mitchell, 2005; Xu et al., 2021).

Yoga interventions

There were nine interventions (25%) designed to provide at-risk young people with exposure to yoga. We recognise that there are different 'styles' or 'traditions' of yoga; however, it is beyond

the scope of this review to individually categorise and explore these variants. For this reason, the following yoga interventions are referred to collectively as 'yoga interventions'. Overall, there were few findings to suggest that yoga interventions are effective for improving mental health outcomes in at-risk young people.

For some studies there appeared to be mixed evidence. For example, Frank et al. (2014) measured positive and negative affect, depression, anxiety, somatisation, emotional distress, and stress symptomatology in a group of students not succeeding in a traditional schooling environment, and found significant pre–post improvements in depression, anxiety, emotional distress, and stress symptomatology (and therefore found no significant within-group effect for affect or somatisation). The trend of mixed findings was also apparent in Mendelson et al.'s (2010), Sarkissian et al.'s (2018), and Velásquez et al.'s (2015) work (which were all for young people living in low socioeconomic or 'urban' environments), with all three studies reporting positive findings in regard to some outcomes, and no significant intervention effects in others. Mendelson et al. (2010) found no between-groups differences in depressive symptoms or positive or negative affect, but did report higher involuntary engagement (i.e., stress responses) for intervention participants at follow-up compared to controls. This was congruent, in part, with Sarkissian et al. (2018)'s findings – they reported significant pre–post improvements in stress, and no significant differences in negative affect. However, they also found a significant improvement in positive affect and resilience. Finally, in regard to studies with mixed findings, Velásquez et al. (2015) reported a significant group-by-time interaction effect for anxiety and depression (favouring the intervention), but found no significant interaction effect for aggression.

Five studies found no significant beneficial effects of yoga interventions. In uncontrolled studies, Kwasky and Serowoky (2018) found no improvements in emotional self-efficacy, and Szoko et al. (2022) found no significant differences in resilience or psychological distress, following their respective interventions. In a non-randomised controlled study, Berger et al. (2009) reported no significant differences at follow-up between intervention and control participants on global self-worth and self-perception. Their study, however, included a control group which participated in physical activity. Fishbein et al. (2016), in a randomised controlled trial, reported no group-by-time interactions for emotional dysregulation, mood, coping, or externalising and social competency behaviours, although their control group was passive (in that, control arm participants had standard-practice lunch time at school). One other yoga intervention study (for youth living in an orphanage in Haiti; Culver et al., 2015) incorporated a control arm that participated in other physical activities (in this case, dance; as well as a wait-list control). Compared to the wait-list control, *change* in trauma-related symptoms was significantly higher (i.e., intervention participants' post-intervention trauma symptomatology scores significantly decreased to a greater degree than controls) in the yoga intervention group, although the intervention group started with a higher baseline score. Despite trends in the data, no differences for trauma-related symptoms and psychological difficulties were reported for any between-groups comparison at follow-up.

Aerobic or resistance exercise

Interventions which involved group sessions of activities primarily designed to improve cardiovascular fitness (e.g., running, cycling) or muscular strength / endurance (e.g., free-weight resistance exercises such as deadlifts) were placed in this category.

Three studies reported findings from interventions that only included 'aerobic' activities (Crews et al., 2004; Draper et al., 2020; Lemstra & Rogers, 2022). Participant risk factors differed across the three studies, although all studies reported some positive intervention effects. Crews et al. (2004) reported a main effect for group allocation on self-esteem following their intervention for low socioeconomic status children, and they found that intervention participants had improved depression scores at post-test compared to controls. Lemstra and Rogers (2022) also found improvements in depression – in their large non-randomised, uncontrolled study of children with obesity, the percentage of participants with depressed mood decreased by 18.4% following programme participation.

Draper et al.'s (2020) work was trauma-focused – they reported significant improvements in two trauma outcomes (validity of cognition and subjective units of disturbance) following unaccompanied asylum seekers' participation in at least running drill session. In addition to the positive findings highlighted above, Crews et al. (2004) found no between-group differences (compared to an 'other physical activities' control group) in trait anxiety, and no group-by-time interaction effect for self-esteem, exemplifying the 'mixed' nature of findings highlighted in this review.

Other interventions involved a combination of aerobic and resistance-based activities, with mixed findings. There were some positive intervention effects for self-evaluative outcomes – Eather et al. (2016) reported a large significant group-by-time interaction effect for improvements in self-esteem, and Annesi et al. (2008) reported significantly greater improvements among intervention participants (compared to an unstructured physical activity control group) in general and physical self-description, and physical self-concept. Annesi et al. (2008) also reported substantial improvements in mood, while Eather et al. (2016) found a medium-sized ($d = 0.7$) non-significant group-by-time interaction effect for improvements in total psychological difficulties. Finally, in a study by Gehricke et al. (2022), children of low socioeconomic status with autism spectrum disorder reported within-group improvements in anxiety following a physical activity intervention – however, there was no evidence of a treatment effect when compared with a LEGO® comparator group.

Surfing interventions

There were four surfing interventions included in the review – two in Portugal (de Matos et al., 2017; Pereira et al., 2020), and two in the UK (Godfrey et al., 2015; Hignett et al., 2018). Both interventions in Portugal were for young people living in residential care, and the interventions themselves were similar – Pereira et al.'s (2020) study, however, was a randomised controlled trial (whereas de Matos et al., 2017, was not) and was over a longer intervention period. Findings from both studies indicated a substantial intervention effect on carer-rated psychological difficulties, but no effect for self-reported psychological difficulties. Additionally, Pereira et al. (2020) reported no significant group-by-time interaction effects for anxiety symptoms, depressive symptoms, or self-esteem. In the UK, both Godfrey et al. (2015) and Hignett et al. (2018) used single-group pre–post designs, and both examined their respective interventions' effects on wellbeing – Hignett et al. (2018) reported no significant differences between baseline and follow-up on their measure of wellbeing (satisfaction with life overall), whereas Godfrey et al. (2015) found substantial improvements in emotional wellbeing. In addition, Godfrey et al. reported substantial improvements in vulnerable young peoples' positive functioning/outlook and self-esteem following their surfing intervention.

Martial arts interventions

Martial arts interventions were grouped together, despite some differences in the specific *martial art* that they included. Three of the four studies investigating martial arts interventions examined self-evaluative outcomes. Blowers (2007) measured self-esteem at three timepoints, and revealed that intervention participants' self-esteem at timepoint three was higher than at timepoint two and baseline – however, *p*-values were not reported. Harwood-Gross et al. (2021) also measured self-esteem, as well as aggression, and found no differences in either outcome between intervention and control participants following a mixed martial art intervention for at-risk young people in Israel. In a small single-group study ($n = 9$), Conant et al. (2008) reported slight pre–post differences (although statistically non-significant) in self-concept and quality of life following their karate intervention for young people with epilepsy. Finally, in an Australian study examining the effects of Capoeira Angola (a non-contact martial art involving dance, music, and singing), Momartin et al. (2019) reported reductions in resettled refugees' psychological difficulties following the intervention period.

Soccer interventions

There was little evidence to support the effectiveness of soccer interventions for mental health outcomes among the included studies in this review. In fact, two of the studies (Richards et al., 2014;

Tilzey, 2020) revealed negative findings (i.e., evidence of worsening of mental health symptomatology). In Uganda, Richards et al. (2014) conducted a randomised controlled trial nested within an observational study of Ugandan adolescents in a post-conflict setting. They measured two outcomes, which were derived from scores on four mental health syndromes local to the Gulu, Uganda area: 'Depression-like syndrome', and 'anxiety-like syndrome'. Male participants' scores on these two measures both worsened (i.e., they exhibit more depression-like and anxiety-like symptoms) following the intervention compared to a wait-list control and observational group, and there were no between-groups findings for girls. Tilzey (2020), however, reported a worsening of internalising and externalising symptoms for girls (underserved newcomer immigrant youth) following participation in the soccer intervention, compared to matched sample means of underserved newcomer immigrant girls who did not participate in the programme. Conversely, Carter et al. (2017) did not report any *negative* findings, however their findings were mixed. Carter et al. found that participants in their intervention group showed fewer internalising symptoms at follow-up compared to controls – however, there was no intervention effect for externalising symptoms.

Basketball interventions

One study (Tester et al., 1999) included in the review examined the effectiveness of a basketball intervention. Tester et al. reported that there was a 44% increase (pre-to-post-programme) in overall self-esteem for at-risk primary school students, and an 18% increase in overall self-esteem for at-risk secondary school students, although *p*-values were not reported.

Negative findings

In trying to understand the characteristics of effective physical activity interventions for children and adolescents at risk of mental health concerns, it is important to also consider the characteristics of studies where negative or iatrogenic findings were reported. There were few similarities across these studies included in the review. Two studies where soccer was the intervention activity reported negative findings, however both assessed different outcomes, were for different populations, and had different intervention doses, making it difficult to gain insight into why negative findings were observed (Richards et al., 2014; Tilzey, 2020). Tilzey (2020) suggested that methodological issues may potentially explain their findings. Richards et al. (2014), however, proposed that the iatrogenic effects they discovered may have been a result of the introduction of new stressors associated with competition. The notion that an unintended shift towards competitiveness among participants occurred is also posited by Kishton and Dixon (1995), who reported a decrease in girls' global self-worth following a multi-sport summer camp intervention.

Discussion

Our primary aim in this systematic review was to assess the effectiveness of physical activity interventions for mental health-related outcomes in at-risk young people, in relation to characteristics of the intervention. Major differences in intervention, population, and outcomes meant that a meta-analysis was not suitable. However, our findings from 36 included studies provide evidence for the effectiveness of physical activity interventions for beneficial effects on more than 60% of outcomes reported in controlled studies, and more than 80% of outcomes reported in uncontrolled studies. These findings generally corroborated those made by similar previous reviews (e.g., Hermens et al., 2017; Lubans et al., 2012; Rose & Soundy, 2020), and reiterate the need for more high-quality research in this field given the high risk of bias observed in this review and in previous reviews. In addition to examining whether physical activity interventions were effective for improving mental health-related outcomes, we aimed to gain insight into which characteristics of physical activity interventions (e.g., target population, intervention type, and 'risk factor' for mental health concerns) were more likely to lead to positive outcomes. In this regard, there was evidence to

suggest that multi-sport interventions are effective, as well as interventions targeting internalising, self-evaluative, or wellbeing outcomes. There was mixed evidence regarding yoga interventions or interventions for young people in out-of-home care in particular, and other characteristics had too few studies to make significant conclusions either way. Additionally, all findings should be considered with caution due to the moderate-to-high risk of bias present. Where sufficient data were available, we provided summaries of effect size – small-to-moderate median effect sizes for internalising and self-evaluative outcomes support the notion that physical activity interventions are effective for eliciting mental health improvements in at-risk young people. We provide additional comment on intervention characteristics (and their association with effectiveness) throughout the discussion.

There is an extensive (and continually developing) evidence base supporting the effectiveness of physical activity (e.g., Biddle et al., 2019) and sport specifically (e.g., Boelens et al., 2022) for improving mental health outcomes in children and adolescents. In comparison, the evidence for 'vulnerable', 'at-risk', or 'underserved' children and adolescents is much less developed. This is a noteworthy gap given the elevated potential for mental health concerns in these at-risk populations (Kieling et al., 2011). It has also been documented previously that as well as a lack of work and evidence on this population in general, there is also a lack of *high-quality* evidence, particularly randomised controlled trials and/or longitudinal insight (Lubans et al., 2012; Rose & Soundy, 2020). Our review provides an updated (and largest-to-date) scope of the literature and reinforces that physical activity interventions *can* be effective for improving mental health outcomes in at-risk young people (although, the effectiveness of an intervention may depend upon the population, intervention, and the targeted outcomes).

It is important to recognise patterns within the 'effective' interventions to inform (a) the design of randomised controlled trials, and (b) meta-analyses which may explore potential moderating pathways of some of the following characteristics. One notable pattern amongst the effective controlled studies in the review was the implementation of multi-sport interventions. Despite twelve of the eighteen positive effects coming from Xu et al. (2021), this observation indicates that a multi-sport approach may be worth considering as a strategy for physical activity interventions for at-risk young people. Overall, four controlled studies and three single-group studies reported positive effects following a 'multi-sport' physical activity intervention, which is promising evidence for the effectiveness of such interventions.

The popularity of multi-sport interventions (and preliminary evidence for effectiveness) in the field may stem from the notion that not all individuals who participate in physical activity are interested in the *same* activities. Although providing one activity may be associated with fewer logistical issues, evidence from our review suggests that providing young people at risk of mental health issues with a variety or choice of activity may foster more positive outcomes. This principle has been applied in similar contexts, such as school physical education (e.g., Pesce et al., 2013), and may also link to self-determination theory literature (for a recent review, see Vasconcellos et al., 2020). Within this theory, it is posited that satisfying one's autonomy, relatedness, and competence in a physical activity context can lead to increased intrinsic motivation for participating in physical activity (and, importantly, outcomes such as improved wellbeing; Ryan & Deci, 2002; Teixeira et al., 2012). Within their review of physical activity interventions for underprivileged youth, Rose and Soundy (2020) identified autonomy support as a potential mechanism for change in mental health outcomes. The prevalence of multi-sport interventions (where, often, participants could choose an activity) in our review suggests that researchers may be making considerations based on psychological theory (although, we cannot be certain of this until more specific review work is conducted). The authors of some studies included in our review did make specific reference to theory having influenced the design of the intervention, and others included theoretical concepts as part of their introductions (see Supplementary Material S3 for further information). One example of a popular theory which features prominently in the field is positive youth development (Bruner et al., 2023; Holt et al., 2017). Hermens et al. (2017) examined life-skills development

interventions, which closely aligns with positive youth development – 12 of the 18 programmes in their review were grounded in positive youth development theory. Thorough exploration of the theoretical foundations of included studies (and, by extension, the interventions reported within them) was beyond the scope of our review, however, we implore researchers to align their work with psychological theory whenever possible. Additionally, application of theory (and perhaps specific theories) *may* be a factor in the effectiveness of an intervention, although we cannot determine this within our extant review and encourage further pursuit of this line of enquiry.

More than 80% of internalising outcomes measured across all controlled studies included in the review were positively affected by a physical activity intervention, indicating the potential for physical activity interventions to foster benefits for outcomes such as depression or anxiety symptomatology, affect, and psychological distress or difficulties in young, at-risk populations. Outside of self-esteem, there were few 'positive' psychological outcomes in general (e.g., 'protective factors', such as self-evaluations, resilience, and wellbeing), which is particularly noteworthy given the potential mechanistic role that these outcomes (e.g., self-perception; Lubans et al., 2016) play on mental health, and child and adolescent development more broadly (Patton et al., 2016). Additionally, all six studies investigating the effect of physical activity interventions on wellbeing included in our review reported positive directions of effect, highlighting the potential salience of promoting protective factors (although, the risk of bias was high). We recommend that researchers advance this line of investigation by further exploring mechanisms (such as self-esteem, coping, or self-perception) of mental health improvements within at-risk populations.

The variation in outcomes, populations, and interventions in our review makes it difficult to confidently assert as to why some (i.e., 63% of between-groups effects in our review, and 75% of those with available data) physical activity interventions are effective, and some are ineffective. Some authors of included studies, however, suggested that a sense of competitiveness amongst participants may have led to iatrogenic effects – although this was not specifically measured and therefore remains speculative. Additionally, although not explored in the studies included in our review, at-risk young people (and specific risk factors under that 'banner') have unique barriers to participation which may ultimately impact the effectiveness of an intervention. For example, physical activity participation among at-risk young people may be impacted by situational and socioenvironmental factors (e.g., violence, crime; Ries et al., 2010). The effectiveness of an intervention may have been influenced by variations in the presence or severity of such factors across different populations. In light of the difficulties pinpointing effective (or ineffective) intervention characteristics, we encourage more work in this field (particularly high-quality RCTs) to advance the evidence base and provide a more concrete foundation for meta-analyses. However, as noted above, the characteristics with the largest body of evidence for effectiveness (e.g., multi-sport interventions) may offer a starting point for such work.

We also recognise that a large proportion of the studies included in our review were single-sport (activity) interventions – we were unable to identify any specific physical *activity* which had greater (more conclusive or higher quality) evidence of intervention effectiveness. Primarily, this was due to the dearth of available evidence for each *activity*. Subsequently, we encourage researchers to review the literature for specific physical activities (perhaps with a broader population focus) to advance our understanding of effective physical activity-based intervention for at-risk young people.

A strength of the current review is that it provides a summation and description of evidence pertaining to physical activity interventions for the mental health of at-risk young people. Nonetheless, these findings should be interpreted with consideration of its limitations. First, in regard to limitations of the evidence, and given extant evidence of the effectiveness of physical activity interventions, we reiterate the need for more adequately powered, high-quality randomised controlled trials. Although there appears to have been some improvements in the field more broadly (see Biddle et al., 2019), for at-risk populations these methodological challenges appear to persist (Hermens et al., 2017; Lubans et al., 2012; Rose & Soundy, 2020). Additionally, when authors reported on multi-component interventions (e.g., physical activity with an educational component), we were not able to infer whether the effects in these studies were derived from the physical activity, the other

component(s) of the intervention, or both. Our inclusion criteria dictated that the interventions were primarily physical activity-focused, but further research design should include methods of isolating intervention components.

In regard to limitations of the review process, we note that it was difficult to capture all relevant articles that would likely fit our criteria, despite our rigorous systematic process. Our non-specific approach (i.e., not restricting our search to specific risk factors, or specific outcomes) meant that some articles would likely have fit our criteria, but may have been missed due to authors not mentioning the risk of mental ill health associated with their population. However, we believe that not including outcomes in our search strategy provided the best opportunity for the review team to include all relevant articles (and, was in line with recent recommendations; see Frandsen et al., 2020; Lefebvre et al., 2022). Additionally, only one reviewer conducted risk of bias assessments, and therefore our reporting of risk of bias was subject to the interpretation of that reviewer. However, we did include a cross-checking reliability process with a second reviewer for a portion of the studies (with a very high agreement percentage) to alleviate any potential errors or biases this may introduce. Additionally, the risk of bias tools we used are well-established and are designed to minimise the risk of subjective interpretation where possible. We also included a cross-checking process for our data extraction, in that 10% of our data were double-extracted (with a very high agreement percentage), instead of entirely double-extracted. The decision to conduct data extraction and risk of bias assessment with one reviewer (cross-checked by a second reviewer) was made based on utilising available resources (e.g., time) while maintaining methodological rigour and reducing the risk of error. Similar processes are common in systematic review literature (e.g., Kenny et al., 2024; Rogers et al., 2020), and any errors that may have occurred are very unlikely to have impacted the conclusions of the study (particularly, given that no meta-analysis was conducted) (Jones et al., 2005). Our review consolidates the notion that physical activity interventions can be effective for mental health outcomes in at-risk young people as a 'general' population, although we recommend review authors narrow their focus onto specific risk factors and populations. In doing so, the opportunity for meta-analysis may arise to provide higher level evidence for the effectiveness of physical activity interventions for at-risk young people.

In this systematic review, we provide updated and comprehensive evidence for the effectiveness of physical activity interventions for mental health-related outcomes in at-risk young people. Additionally, we present insight into the characteristics of physical activity interventions which may lead to more positive outcomes, which may assist those designing interventions in the future. We offer recommendations for future research at the individual study level (higher quality, powered randomised controlled trials) and the review level (focus on specific risk factors, which opens the potential for meta-analyses or a review of reviews). Our findings provide additional evidence that physical activity may be a valuable avenue for the prevention of mental ill health for at-risk young people, in addition to its other well-evidenced health benefits.

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