Starting Well

Physical activity interventions on mental health in children and young people in school-based and other settings: A review of reviews

Report by Dr. Nicola McWhannell, University of Chester
n.mcwhannell@chester.ac.uk

Commissioned by Active Cheshire

August 2022

Contents

List of Abbreviations

Physical Activity	PA
World Health Organisation	WHO
Chief Medical Officer	CMO
United Nations Children's Fund	UNICEF
High Intensity Interval Training	HIIT
Supportive, Active, Autonomous, Fair, Enjoyable (principles)	SAAFE

List of Tables

Executive Summary

- The most frequent mental health conditions in children are anxiety disorders, followed by behaviour disorders, mood disorders (including depression) and substance use disorders. It is well established that participation in physical activity (PA) can elicit mental health benefits such as reducing symptoms of anxiety and depression and enhancing wellbeing and quality of life. The proportion of children meeting the recommended PA guideline of ≥60min.day-^{1} is low, with PA levels declining with age. More children and young people are experiencing mental health problems following the recent Coronavirus disease 2019 (COVID-19) pandemic, therefore low-cost, high reach strategies, such as school-based interventions, that can help improve the holistic mental health are needed.
- This report aims to gain better understanding of the effect of PA interventions on mental health in school-aged children in both school and other settings to inform the strategy and planning of future programmes/initiatives.
- Overall, the findings indicate that PA interventions based in school or other settings can have a positive impact on mental health outcomes in children and young people. Despite only small-to-moderate effects, reductions in symptoms of anxiety, depression and externalising problems are evidenced, alongside improvements in resilience, wellbeing, self-esteem, body image, self-concept, and quality of life. Some positive outcomes are more pronounced in overweight/obese populations.
- School-based settings may offer a relatively high reach, low cost, supportive and structured environment for interventions that could benefit the holistic mental health of children and young people. Interventions appear to have greater effect on adolescent compared to child populations, so interventions implemented in secondary schools, or to secondary school-aged children are encouraged.
- Multi-component interventions that include PA alongside an additional mental health literacy or education component may offer enhanced value in terms of promoting positive mental health. Whilst the improvement in PA levels should remain a key outcome of interventions, careful consideration should be given to: intervention component(s), mode of activity, dose of activity and measurement of physical and psychological outcomes. Despite the influence of the length and PA remaining unclear, short-medium term interventions including non-competitive sports activities, yoga-based, and resistance HIIT activities in PA interventions should be considered.
- To positively impact the mental health of children and young people, those designing and implementing PA interventions should allocate energy, time and resources into multi-component, short-to-medium term interventions (>3m-<1y), that include a component of mental health literacy, alongside different modes of PA, that encourage engagement and positive experiences within a supportive environment, such as school. The framework principles of Lubans et al. (2017), SAAFE, should be included in both consultation and strategic stages of planning.
- The limitations of this report include the quality of the reviewed research studies and the heterogeneity of PA intervention design, mode and dosage, making it difficult to identify optimal intervention characteristics for mental health.

1. Introduction

Mental health has been defined by the World Health Organisation (WHO) as, a "state of wellbeing that enables people to cope with the stresses of life, realise their abilities, learn well and work well, and contribute to their community" (WHO, 2022b). The broad term of mental health covers mental disorders, psychosocial disabilities and other mental states associated with significant distress, impairment in functioning, or risk of self-harm (WHO, 2022a). One in six children were identified as having a probable mental health disorder in 2020, which was a 6% rise from 2017 (NHS, 2021). A recent UNICEF report examining child and adolescent mental health stated that at least 13% of children aged 10-19 live with a diagnosed mental health disorder, with anxiety and depression constituting more than 40% of mental-health disorders in young people (UNICEF, 2021). There is initial evidence that the coronavirus pandemic is exacerbating the rising trend (Nature, 2021; NHS, 2021). The most frequent mental health condition in children is anxiety disorders, followed by behaviour disorders, mood disorders (including depression) and substance use disorders (Merikangas et al., 2009). The Mental Health Foundation (MHF) emphasises that the emotional wellbeing of children is equally as important as their physical health and highlights key factors that can help to keep children and young people mentally well. These include: regular exercise, play, balanced diet, supportive family and school environments, and participating in activities (MHF, 2022).

The benefits of regular physical activity (PA) include improved physical fitness, cardiometabolic health, bone health and reduced adiposity as well as improved cognitive function and mental health (WHO, 2020). Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure (Neill et al., 2020; WHO, 2020). In addition to the well documented physical health benefits, participation in regular PA is associated with mental health benefits, including quality of life and wellbeing (WHO, 2020). Current PA guidelines for children and young people (5-18yrs) state that engagement in at least 60 minutes per day of moderate-to-vigorous intensity PA is required to achieve health benefits (CMO, 2019). All forms of activity, such as physical education, active travel, after-school activities, play and sports, are encouraged, including activities that improve movement skills, muscular fitness, and bone strength. The guidelines also

encourage minimising sedentary activity (CMO, 2019). Many school-aged children fail to meet the recommended daily PA guideline of ≥60 min.-^{1} (Guthold et al., 2018; Marques et al., 2020). Recent articles reported that PA levels in children tend to decline with age, citing that only 28% of boys and 19% of girls aged 11-12y, and 21% of boys and 11% of girls aged 16-17y achieved the recommended PA guideline (Jago et al., 2020; Marques et al., 2020).

The association between PA and psychological benefits are widely reported in literature, but effects are often small-to-moderate and research designs are often weak (Biddle & Asare, 2011). In general, evidence suggests that engagement on PA can lower levels of anxiety and depression and increase self-esteem in young people (Ahn & Fedewa, 2011; Biddle & Asare, 2011; Hale et al., 2021; Korczak et al., 2017; Rodriguez-Ayllon et al., 2019). Findings from the SEYLE (Saving and Empowering Young Lives in Europe) study (McMahon et al., 2017), which surveyed 11,110 adolescents from ten European countries, found that more frequent participation in PA and sport were associated with higher levels of wellbeing and lower levels of anxiety and depressive symptoms, in both males and females. It is suggested that positive mental health outcomes occur due to a number of biopsychosocial influences, including changes to brain function, opportunities for social interaction and development of competence (Lubans et al., 2016). Although the underlying mechanisms explaining mental health changes as a result of PA remain unclear (Biddle et al., 2019), it is important to improve our understanding to develop better, more effective interventions (Lubans et al., 2016).

In light of the anticipated rise in related psychological problems (Torales et al., 2020) following the recent Coronavirus disease 2019 (COVID-19) pandemic, it is important to explore low-cost, high reach strategies that can help improve mental health for children and young people. The established associations reported between PA and mental health outcomes are largely from cross sectional studies, which only explore relationships between variables in a snapshot of time.

Intervention studies seek to observe change and effect by manipulation of variables in a specific environment over time, to better understand outcomes, inform future programmes, and explore potential causal relationships. Schools provide an ideal environment for programme delivery due to the contact-time, structure and support

available to encourage participation. Educational settings already have a structure in place for opportunities for physical and mental health development through curriculum provision. Interventions within a school-based setting could, with careful planning, enhance physical and mental health further. There is strong evidence that school-based PA interventions can increase objectively measured PA in children (Riso et al., 2014). Positive mental health outcomes as a result of school-based and community-based interventions have been reported (Das et al., 2016; Neil & Christensen, 2009). Interventions based in the school setting can also minimise potential barriers to participation such as time, transportation, organisation and cost, offering a convenient setting, whether it be as part of the curriculum or through extra-curricular activities (Barrett & Pahl, 2006).

This report will focus only on the systematic review or meta-analysis of intervention studies exploring the effect of school-based PA intervention on mental health outcomes in children and adolescents. This report acknowledges, and aims to complement, the previous review of reviews by Biddle and Asare (2011) and the more recent updated review (Biddle et al., 2019), by including articles from 2018 to 2021 within the report. Whereas the articles by Biddle and Asare (2011) and Biddle et al. (2019) reviewed both intervention and cross sectional studies, this report focuses only on intervention studies. As the review of review format allows the exploration of several mental health outcomes within PA intervention studies, this report will be structured by setting, rather than by outcome.

2. Methods

2.1. Search strategy and Inclusion Criteria.

Four electronic database searches using CINAHL Plus with Full Text, SPORTDiscus, Web of Science Core Collection or MEDLINE® and The Cochrane library were carried out in June 2022. The search strategy was developed by the author and reviewed by a subject librarian at the University of Chester. The terms used in the searches reflected the exposure variables related to PA (sport, fitness, exercise, walking etc), and mental health outcome variables (mental health, anxiety, depression, wellbeing etc), with the additional search variables relating to population (children, youth, adolescents, etc), setting (school, school-based), method (intervention) and type of document (review). This resulted in the following

search criteria being used: physical activity OR exercise OR sport OR fitness OR walking OR cycling AND mental health OR anxiety OR stress OR depression OR wellbeing OR well-being AND Children OR youth OR adolescents OR boys OR girls OR young AND School OR school-based AND Review Article. To ensure consistency of searches, the terms and criteria were adapted to suit the requirements of each database. To be included in this review, articles had to meet the following inclusion criteria: 1. Be systematic reviews or meta-analysis, 2. Report outcomes of PA interventions and at least one mental health outcome variable, 3. Include outcomes concerning school-aged children, 4. Be published between 2012 and 2022. Only full-texts articles were considered for inclusion and articles available in English.

2.2. Identification of relevant studies

The literature search returned 291 titles. Titles and abstracts of potentially relevant articles were screened based on the relevance to the report aims and were exported to Endnote (X9). Following this, eighty-seven articles were further screened, resulting in seventy-eight being removed due to not meeting the inclusion criteria. Articles that focused solely on specific populations such as overweight and obese populations, or clinical populations, were excluded. Nine systematic or meta-analysis review articles were therefore included for the present review of PA interventions and mental health in young people.

As the aim of this report is to gain better understanding of the effect of PA interventions on mental health, to inform future programmes, the results will be presented according to intervention setting, rather than by mental health outcome. This is because each review article includes a range of different mental health outcomes, terms and composite measures. This report has chosen not to discuss intervention effects by specific mental health categories (e.g. anxiety, depression, wellbeing) separately, but rather focus more productively on discussing the intervention effects on mental health within PA intervention setting (e.g. schools and other settings incl. community, summer camps, clinical). This report will initially discuss PA interventions from school-based settings and other settings, followed by further discussion of intervention characteristics, including design, mode of PA, duration, and frequency, to better inform interested parties in suitable approaches

when designing interventions. Both aspects will be summarised in the concluding section of this report.

3. Results

Nine articles reviewed evidence concerning PA interventions and at least one mental health variable in children and young people.

3.1. Study characteristics

Of the nine articles, eight included studies using broad modes of PA (aerobic activities, resistance exercise programs, fitness training, games, Crossfit, dance and yoga), and one explored the intervention effect of yoga activities alone. All articles included studies which were both single component interventions (PA only) or multicomponent interventions (PA plus education or behavioural support). Four reviewed the effect of PA (single component) interventions on mental health outcomes, while four included both single and multicomponent studies in their work. Four articles specifically reviewed only school-based intervention studies, and five reviewed interventions on school-aged children and young people (4-18yrs) in a variety of settings (clinical, community, summer camps) including schools.

3.1.1. School-based interventions

Four of the nine reviews included PA interventions which were school-based (Andermo et al., 2020; Hale et al., 2021; Rafferty et al., 2016; Vaquero-Solis et al., 2020). The remaining five articles included some school-based studies in their review (Brown et al., 2013; James-Palmer et al., 2020; Neill et al., 2020; Rodriguez-Ayllon et al., 2019; Spruit et al., 2016) and will therefore be discussed where appropriate in this section.

There is evidence that school-based interventions can have a positive effect on the mental health of children and young people. In most cases, school-based interventions are delivered by teachers or, in some cases, professionals (coaches/instructors) within the school environment. Two recent reviews exploring the effect of school-based PA interventions on mental health outcomes (Andermo et al., 2020; Vaquero-Solis et al., 2020) report favourable results. Both articles cite the reduction of internalising mental health problems, like anxiety, and increasing

or improving positive mental health variables, like resilience, quality of life, self-concept, wellbeing, body image. Andermo et al. (2020) performed a meta-analysis on thirty school-based PA interventions (single and multicomponent). The meta-analysis found school-based PA interventions to have a significant positive effect on anxiety, resilience and wellbeing in children aged between 8-17yrs. Intervention lengths varied between 4 weeks and 4 years and compared intervention effect with controls where participants took park in either their usual PE lesson, another physical activity, a non-physical activity, or no activity (waitlist control). The authors categorised interventions to distinguish between different types of intervention (single or multicomponent), creating one single component category “body” (improving body strength PA), and three multicomponent categories: “body-education” (PA plus intervention containing learning elements), “body-mind” (PA plus intervention aiming to strengthen mental processes) and “body-education-mind” (PA plus intervention containing learning elements and aiming to strengthen mental processes). The type of intervention did not have any moderating effect, but age was found to moderate effects in internalising mental health problems (including worries, anxiety, depressive symptoms). Older children (>12yrs) experienced favourable or no effect, but younger children experienced negative or no effects. This may provide a useful rationale for a focus of PA interventions in secondary schools, particularly as the average age for the onset of anxiety has been reported to be 11 years old (Kessler et al., 2005), and mood disorders (including depression) are reported to commonly manifest in late adolescence (Merikangas et al., 2009).

In contrast, an earlier systematic review (Rafferty et al., 2016) reported some positive outcomes in younger children (6-12yrs) following PA interventions assessing a broad range of outcomes within wellbeing, including quality of life, wellness, happiness, life satisfaction, self-concept, autonomy and relationship. Whilst over 70% of interventions reported a positive effect of PA, only a third of studies found significant intervention effects on self-worth, quality of life, autonomy, and relationships, with self-worth only significant in obese children. Aside from the range of mental health outcomes assessed and reviewed in a variety of studies, the inclusion of at-risk groups within several of the review articles also impacts the ability to ascertain genuine intervention effect and the impact on the general

population. Rafferty et al. (2016) reviewed the effect of school-based PA interventions on children's wellbeing, where interventions were both PA only and multi-component interventions. Interestingly, whist the PA only interventions (n=3) reported significant effect on PA, the effect on wellbeing was not significant. Significant wellbeing outcomes appeared to be more prevalent in multicomponent interventions (n=8) whereby PA was delivered as part of broader intervention programmes which included components like nutritional information, education of healthy body image, health education and family engagement. Whilst this observation is only inferred from this review, and not from meta-analysis or moderator analysis, it may be a useful observation to consider when designing interventions.

Improvements in symptoms of anxiety and/or depression in children and young people (3-21yrs) were reported from yoga-based interventions in a recent systematic review (James-Palmer et al., 2020). Most of the interventions reviewed by James-Palmer et al. (2020) were school based (n=13), with a small portion delivered in different settings including clinical (n=2), community (n=1), orphanage (n=1) and summer camps (n=2). When studies assessed anxiety and depression together, 58% reported improvements in anxiety and depression. When assessed separately, improvements were reported in 70% and 40% of studies for anxiety and depression respectively. The interventions reviewed included rather heterogeneous methodologies, including numerous anxiety and depression assessment measures, a range of dosage, types of yoga and effects measured against no treatment or regular PE lessons. The differences in intervention setting, combined with the heterogeneity of intervention design makes it challenging to dissect and identify what aspects of the interventions worked and why. It is however encouraging that, in general, many studies reported some type of improvement in symptoms of anxiety and/or depression in children and young people in school-based or structured settings.

Yoga interventions were also included in a broader systematic review of PA interventions on mental health and wellbeing of adolescents (11-19yrs) by Hale et al. (2021). The review also included multi-component interventions with PA aspects, including aerobic activities (n=21), yoga (n=12), resistance training (n=10) and team

sports (n=6), alongside health education sessions and behavioural skills sessions. Despite the variation in treatment length, duration, and frequency, findings suggest that PA interventions are useful in improving quality of life (in overweight and obese only) and psychological wellbeing.

Vaquero-Solis et al. (2020) explored the motivational intentions of children and adolescents participating in school-based PA interventions to gain a better understanding of the mental health benefits, focusing on psychosocial variables (motivational processes, self-esteem, body image, quality of life) as well as the physical health benefits. The review sought to explore the theoretical models that school-based interventions are often based on and what effect they have. Most interventions studies were based on Self-Determination Theory of Ryan and Deci (2002); that fulfilment of autonomy, competence and relatedness can influence wellbeing. Most of the intervention studies exhibited small to medium positive effect on PA, and most had a small effect on the intention to be physically active. Seventeen per cent of studies revealed effects of a range of psychosocial variables, but the authors highlight that conclusive intervention effects are difficult to obtain due to the variety of methods used, the range of effects analysed and the time limitations within interventions. In relation to intervention length, short-term PA interventions (<3m) presented fewer effects, than interventions with a longer duration (>3m <1y), but excessively long-interventions can end in stagnation, where teachers may potentially struggle to maintain motivation and attention over time. Vaquero-Solis et al. (2020) do however offer a number of useful recommendations from their review, which include the use of mixed method interventions, and utilising technology (including web-based interventions and wearable devices) to improve collaboration between teachers, families and peers, and reinforce activity behaviour. The evidence that wearable technology devices can promote motivation to improve or maintain PA is however mixed (Girginov et al., 2020).

School-based interventions were also included in the systematic review and meta-analysis articles from Brown et al. (2013) and Neill et al. (2020). Brown et al. (2013) explored the impact of nine PA interventions on depression in children and adolescence (5-19yrs), while Neill et al. (2020) reviewed the effect of interventions with a PA component on depression, anxiety and stress. Whilst no overall effect

was reported by Neill et al. (2020), Brown et al. (2013) reported a small but significant treatment effect for depression, but many of the studies targeted at-risk groups (e.g. obese, youth offenders, low SES) alongside general population groups. Four of the nine included interventions that were school based as part of curriculum PE or as an afterschool activity session. The PA aspects of the interventions included aerobic exercise, yoga and mindfulness activity, health education and sport/games practices, making it difficult to identify the most effective type of intervention to positively effect depression. The authors highlight that the interventions that were short-term (<3m), high quality, and included both education and PA aspects to specific groups (single-gender; those targeting overweight or obese) contributed most to the reduction in depression (Brown et al., 2013).

3.1.2 Interventions in other settings

Five articles of the nine articles within this review included interventions in other settings (Brown et al., 2013; James-Palmer et al., 2020; Neill et al., 2020; Rodriguez-Ayllon et al., 2019; Spruit et al., 2016). The range of settings included community-based settings, clinical/GP referral settings, youth detention settings, summer camps and an orphanage. In line with this, interventions were delivered by a range of facilitators including personal trainers, physiotherapists, instructors, researchers, and coaches. Of the non-school based interventions reviewed, Brown et al. (2013) reported that the greatest reduction of depression was found in those studies that were single-gender and those targeting overweight/obese children and adolescents, which were based in clinical/GP referral settings. In contrast, the meta-analysis conducted by Neill et al. (2020) reported no overall effect, despite the inclusion of at-risk populations (overweight/obese), interventions conducted in both clinical and community settings, and interventions that were single-gender. The complexity of measuring mental health outcomes and PA included in the broad and diverse range of studies discussed in this review (8 different countries, a range of settings and populations, variety of PA modes and intervention durations) make it difficult to isolate favourable intervention characteristics and may have dampened overall effect in the analysis. The authors do however highlight that the promotion of PA should remain an important preventative mental health strategy for children and young people.

Rodriguez-Ayllon et al. (2019) explored the effect on PA only interventions on mental health outcomes. Most interventions lasted between 8-28 weeks, 2 to 3 times per week, in activities that ranged from mind-body exercise programs, aerobic exercise programs, resistance exercise programs, combined exercise programs (aerobic + resistance), football, exergames and CrossFit. The findings suggest that PA has a small but significant positive effect on mental health, but these observations were only found in adolescents and not children. Akin to the school-based review by Andermo et al. (2020), the findings highlight potential age specific effects, but the findings should be viewed with caution as only 3 of the 15 intervention studies included in the analysis were focussed on children. Whilst a positive effect on mental health outcomes was reported, Rodriguez-Ayllon et al. (2019) conducted further analysis to explore activity length within interventions. The marker of 60 mins based on the WHO recommended daily PA guidelines was used to compare programs. Interventions that included activities for >60min significantly improved mental health compared to programs of <60min. These outcomes support the importance of children and young people meeting the PA recommended guidelines of >60min of daily PA. Thus, promotion of PA through intervention programmes should seek to provide and/or contribute significantly to daily PA of at least 60 mins per day.

Spruit et al. (2016) conducted a meta-analysis on PA interventions on psychosocial outcomes in adolescents (11-18yrs). The studies included a range of settings and samples, which were largely community-based (incl. school) or clinical, and at-risk (overweight/obese, clinical diagnosis, juvenile delinquents) and general paediatric population. Four separate meta-analyses assessed the overall effect on PA interventions on externalizing problems (any type of aggressive or delinquent behaviour, or conduct problem), internalizing problems (anxiety, depression, and/or emotional problems) and self-concept (global measures of self-concept, self-esteem, or self-worth). The findings indicate that PA interventions significantly reduced externalising and internalizing problems and increased positive self-concept in adolescents, as a significant small-to-medium effect was reported. Further moderator analyses of study sample and intervention characteristics were conducted to explore which factors moderate the effect of PA interventions on the above outcomes. The gender ratio of the sample appeared to moderate the strength

of the effect on internalising problems, with stronger effect in studies with fewer males. Stronger effects were also found within samples with a clinical diagnosis. The type of PA within the intervention appeared to moderate the effect on self-concept, with larger effects found in interventions with aerobic exercise activity compared to sport-based interventions. The authors suggest that as the competitive aspect of winning or losing a game can have increased or adverse effects on self-concept, non-competitive exercise activities can improve a sense of wellbeing (feeling well). This outcome may support the inclusion of non-competitive activities within PA interventions.

3.2. Section Summary

- School-based PA interventions can have a positive impact on mental health outcomes.
- PA Interventions in other settings also report positive outcomes in mental health
- The reduction of symptoms of anxiety and depression and externalising problems are highlighted, alongside improvements in resilience, wellbeing, self-esteem, body image, self-concept, and quality of life.
- Improvements in quality of life and self-worth and reductions in depression were more pronounced in overweight/obese groups.
- Interventions appear to have greater effect on adolescent compared to child populations
- Intervention design is important where the component, mode, dose and outcomes measurement are key considerations.
- Improvement in PA levels should remain a key outcome of interventions
-

3.3. Intervention characteristics

3.3.1. Intervention design

Many of the articles reviewed acknowledge the difficulty of identifying beneficial or optimal design aspects due to the heterogeneity of intervention designs discussed within their reviews (Andermo et al., 2020; James-Palmer et al., 2020; Neill et al., 2020; Rafferty et al., 2016; Rodriguez-Ayllon et al., 2019). The importance of intervention design was highlighted in a number of articles (Hale et al., 2021; James-Palmer et al., 2020; Rafferty et al., 2016; Rodriguez-Ayllon et al., 2019;

Spruit et al., 2016). If we are seeking to improve mental health outcomes through the PA component, there is a need to understand and determine the most suitable approach to better inform intervention characteristics (Neill et al., 2020). Intervention design across the review articles ranged from randomised controlled trials (RTCs), non-randomised trials and single group pre-post interventions (no control measure). Where control groups were included, either regular PE lessons, waitlist groups or alternative treatments (eg. mindfulness) would be used as the comparator. When interventions were delivered in schools, they were usually implemented in place of regular PE or as afterschool sessions. The range of differences between intervention methodologies makes it extremely difficult to recognise and highlight key aspects of the design which may be causal.

Spruit et al. (2016) and (Rodriguez-Ayllon et al., 2019) both stress that poorly designed interventions could lead to negative or harmful effects on psychosocial wellbeing. It is therefore important to discuss intervention design in further detail to gain a more informed perspective when designing interventions for future implementation. For the purpose of this report, the following three aspects of intervention design will be discussed further: 1. Component (PA only or PA plus additional (multi) component(s) such as education, nutrition, skills. 2. Activity Mode (type), concerning the activity delivered or prescribed in the intervention and 3. Dosage, the length, duration and frequency of the intervention

3.3.2. Single vs. Multi-component interventions

A number of the interventions included in the review articles were multi-component, whereby PA is combined with additional components such as health education (Andermo et al., 2020; Brown et al., 2013; Hale et al., 2021; Neill et al., 2020; Rafferty et al., 2016; Spruit et al., 2016), nutrition(Neill et al., 2020; Rafferty et al., 2016; Vaquero-Solis et al., 2020), mindfulness (Andermo et al., 2020; Brown et al., 2013), behavioural skills sessions (Hale et al., 2021), limiting screen time (Vaquero-Solis et al., 2020), family engagement (Rafferty et al., 2016). All but one of the articles (Neill et al., 2020) reported some small-to-medium positive effect on mental health variables from interventions that included either single (PA-only) component or multicomponent design. Of the studies that performed moderator analyses for intervention component (Andermo et al., 2020; Spruit et al., 2016), no moderating

effect was found, so the question of whether single or multi-component intervention designs are more favourable remains unclear. It is however encouraging that small-to-moderate positive outcomes have been reported from both types of intervention design.

Multi-component PA interventions containing mandatory elements are deemed most effective in improving PA in children (Riso et al., 2014). Multi-component interventions are also encouraged by the WHO (2009), who published a report on interventions on diet and PA, suggesting that interventions that are most effective in modifying adolescent lifestyle factors (e.g. physical inactivity, poor diet) are ones that include PA and additional health education components. The report believes that the same interventions can show a similar impact on mental health. The WHO (2009) also supports the use of multi-component interventions within the school setting, and interventions which are adapted to the school context/environment are the most successful. The inclusion of components which can be embedded in curriculum where children are taught by teachers, in a supportive environment, with parental involvement are recommended for effective lifestyle change (PA) and therefore may also have a similar impact on mental health. There are, acknowledged earlier, several multi-component PA interventions that include health literacy and education components as part of broader interventions which aim to improve well-being. The difficulty lies in isolating the causal aspects of any reported change in multi-component interventions due to the heterogeneity of different components. It is however encouraging to consider that many positive outcomes could be achieved on several variables using multi-component interventions. Hale et al. (2021) promotes the use of multi-component interventions and suggests that multi-component intervention designs that focus on mental health literacy may provide a convenient, cost-effective method to reducing the prevalence of mental health problems in later life, by promoting psychological wellbeing and self. The importance of health literacy is advocated by the World Health Organisation who suggest that greater health literacy can develop individual resilience and improve health and well-being (Kickbusch et al., 2013); Hale et al. (2021) suggest that the addition of education sessions could enhance individuals' mental health literacy and emphasise the broader important link between PA and positive mental health. Whilst this might be something that schools consider more permanently within

curriculum time, continued research in this area should consider the importance and potential impact of multi-component characteristics when schools or local initiatives design school-based interventions.

3.3.2. Intervention mode: Type of physical activity

Within the reviewed articles, the heterogeneity in intervention activity types was vast. The description and detail of these PA components within interventions was varied, making it difficult to evaluate specifically and draw clear conclusions. The following types or modes of activity were often reported in PA interventions: sport (various), dance, circuit training, HIIT, sport-skill development, aerobic activities, yoga, skipping, playground activities, Acro sport, resistance training. Some interventions also combined PA activities e.g. yoga and sport. Most review articles included interventions which used a range of PA activities, making it difficult to identify whether a certain type or mode of PA yields greater outcomes than others. Two papers explored the effect PA type had on intervention effect in further analyses (Hale et al., 2021; Spruit et al., 2016). For self-concept, moderation analysis found that greater intervention effects were found from aerobic exercise activities, compared to sport-based activities (Spruit et al., 2016). Hale et al. (2021), reported an intervention where resistance HITT training/activities lead to larger effects on wellbeing compared to aerobic-based carried out in regular PE lessons (Costigan et al., 2016). Positive mental health outcomes have been reported following resistance-based activity HIIT interventions in adolescents in previous literature (Eather et al., 2016; Smith et al., 2018), providing support for the effectiveness of resistance-based activity and HIIT in reducing mental health problems in adolescents (Leahy et al., 2020).

Sport-based activities were highlighted by Rodriguez-Ayllon et al. (2019) within the observational analysis of her systematic review. The authors' synthesis of recent cross sectional and longitudinal papers explores the association between PA and mental health in different age groups. Type of activity was acknowledged as a contributing factor. Activities with a high aesthetic focus (such as dance and gymnastics) are associated with higher levels of body dissatisfaction compared to non-aesthetic activities (Schneider et al., 2013). The authors suggest that

participation in team sports (without any aesthetic focus) is the type of PA most strongly associated with lower levels of mental health problems in young people.

Positive mental health outcomes are evident from the yoga-based interventions discussed in this review (Hale et al., 2021; James-Palmer et al., 2020; Rodriguez-Ayllon et al., 2019), providing some support for yoga activities improving symptoms of anxiety and/or depression (James-Palmer et al., 2020). In a recent systematic review of yoga interventions for anxiety reduction among children and adolescents, 16 yoga interventions were included (Weaver & Darragh, 2015). The authors highlight that, while reduced anxiety was evident after nearly all yoga interventions, further research is needed to enhance the ability to generalize and apply yoga to reduce anxiety because of the variety of study populations, variable outcome measures and study design limitations. Yoga-based activities should be considered as a viable and potentially efficacious strategy for improving child and adolescent health (Khalsa & Butzer, 2016), despite the acknowledged variability in yoga intervention characteristics, type of yoga practice, length, number and duration of sessions.

It is important to acknowledge that the relationship between mental health and PA can be influenced by several other factors. Factors such as enjoyment, perceived physical competence, self-concept, resilience and peer support may potentially influence and/or explain positive or negative changes in mental health (Rodriguez-Ayllon et al., 2019). Evidence suggests a causal relationship between physical self-concept (perceived competence, perceived appearance, and perceived fitness) and mental health (global self-concept, self-esteem) whereby positive changes in physical self-perceptions can lead to improved mental health outcomes, like self-esteem (Lubans et al., 2016).

3.3.3. Dosage: Intervention Length, Duration and Frequency.

The range of PA dosage described in each review is vast and often poorly reported and analysed across reviews. This highlights the variability of interventions and the challenge of defining or discussing optimal intervention dosage. In terms of PA effect on mental health, the optimal dosage therefore remains unclear. This section will therefore highlight main outcomes and key suggestions from the review papers

regarding intervention length, duration (of individual sessions) and frequency (of sessions).

The meta-analysis by Spruit et al. (2016) found that the length and frequency of interventions did not influence the effect of PA interventions on internalising problems, externalising problems or self-concept. This seems plausible as many studies highlight the methodological differences in intervention design and cite the heterogeneity limitation to conclusive recommendations. Some studies did explore dose further and provide tentative suggestions. The suggestion of a relatively short-term intervention (<3m) by Brown et al. (2013) is also supported by (James-Palmer et al., 2020), recommending that intervention lengths between 6-12 weeks can elicit positive mental health outcomes. In contrast, Vaquero-Solis et al. (2020) recommend longer interventions (>3m <1y) but warn about potential stagnation in excessively long-interventions (>1y). A session duration of at least 30min, 2-3 times per week is recommended from the yoga-based intervention study (James-Palmer et al., 2020). Whereas longer durations were supported by Rodriguez-Ayllon et al. (2019) who reported significantly improved mental health outcomes from interventions that included session activities of >60min compared to programs with sessions of <60min. The frequency of sessions is highlighted by Hale et al. (2021) as a key component of effective intervention development but offer no specific suggestion of optimal frequency.

3.3.4. Summary section

- The heterogeneity of PA intervention design, mode and dosage make it difficult to identify optimal intervention characteristics for mental health.
- There is an additional challenge in understanding the causal influence of health promoting components in multi-component interventions, but challenges are also present in single component interventions due to the variety of mode, length, duration and frequency.
- Interventions that include multi-components that include PA alongside an additional mental health literacy or education component may offer enhanced value in terms of promoting positive mental health.

- The most effective mode of PA on mental health remains unclear, but researchers or health promotional initiatives should consider the inclusion of non-competitive aerobic activity, yoga-based activities and resistance HIIT activities.

4. Summary

The present report reviews findings from nine PA interventions and evaluates their effectiveness on mental health outcomes in children and young people. The report focusses largely on school-based interventions, but also offers insight into interventions from other settings. The report offers insight into the intervention effects of PA on a range of mental health outcomes and also explores intervention design, mode and dose of PA to improve understanding and inform strategies when designing interventions in the future.

In general, findings suggest that PA interventions can offer a worthwhile contribution to improving mental health outcomes in children and young people, with more significant outcomes reported in adolescent samples. Positive intervention effects were reported in both school-based interventions and interventions in other settings, for several mental health outcomes including anxiety, depression, wellbeing, self-concept, wellbeing, reliance and quality of life, although some effects were only significant in at-risk groups in clinical settings. Consistent with previous research (Biddle & Asare, 2011; Rafferty et al., 2016), the small but positive effects achieved from PA interventions across different mental health outcomes do not offer clear conclusive evidence. This is likely due to low quality, weak intervention designs, and heterogeneity across methodologies including assessment measures and sample diversity, where studies of 'healthy' samples were reviewed with studies of at-risk samples, including mild or clinical mental health conditions and overweight or obesity. Further research is required to ascertain why physical activity interventions yield positive psychosocial outcomes through high quality intervention evaluations (Spruit et al., 2016).

Both schools-based and other settings appear to offer a useful platform for PA interventions. Whilst the results within each setting offer small but positive benefits to mental health, it could be suggested that, if the intention of the PA intervention is to promote mental health and improve overall wellbeing in the general school-age

population, schools may be the most suitable setting. This is due to the familiar and supportive environment, the high proportion of time spent in school and the access to tuition, space and equipment. If the intention of the intervention is to support and reduce mental health problems in specific populations (at risk, overweight or obese, depressed etc), other settings may be more favourable as they can offer specialist care and support and a non-school setting may also minimise a sense of embarrassment among peers. The preference of intervention setting should therefore consider intervention aims and target group at the consultation stage of intervention design.

In terms of design, multi-component interventions could offer additional value in terms of promoting PA and positive mental health through the inclusion of educational or health literacy components alongside PA components. It is suggested an emphasis on mental health education could improve intervention effectiveness in improving well-being and decreasing mental health problems in adolescents from the general population (Hale et al., 2021). The most suitable type or mode of PA for mental health benefits cannot be concluded from this report. The lack of evidence of any moderating effect of type of PA on mental health outcomes reported (Andermo et al., 2020; Spruit et al., 2016) supports this. Non-competitive aerobic activities were found to generate stronger positive effects on self-concept compared to competitive sport activities (Spruit et al., 2016). Resistance and HIIT activities were also acknowledged (Hale et al., 2021) as potentially being effective modes for reducing mental health problems in adolescents. There is also support for yoga-based activities improving anxiety and depression in children and young people (James-Palmer et al., 2020). A relatively recent study explored the effects of an 8-week PA programme combining learning a new sport and a mindful yoga practices, found significant improvements in self-esteem, resilience and happiness (Yook et al., 2017). The range of activity modes included in the reviews discussed demonstrates the wide variability of intervention designs. There may also be a range of factors that interplay with mode of physical activity, such as delivery style, characteristics of the instructor/facilitator, the aims of the activity or any competitive outcomes. All of which have the potential to engage or disengage young people in PA (Ntoumanis et al., 2012; Rutten et al., 2007; Spruit et al., 2016). Interestingly, the outcomes from a longitudinal study (Brunet et al., 2013) cited in (Rodriguez-

Ayllon et al., 2019) found that participation in sport-based activities during adolescence was associated with decreased levels of adulthood depression, promoting sports participation, not overall physical activity as having the strongest association with mental health. This could be explained by the social benefits experienced from sports-based activities (ref).

There is also a case for just increasing PA, regardless of mode. In accordance to PA guidelines, children and young people should engage in at leave 60min of daily PA to gain physical and mental health benefits (CMO, 2019). Often studies fail to fully describe activity duration or intensity, so it is difficult to ascertain PA load. There is evidence to suggest that meeting the recommended >60 min/day of PA within interventions can elicit improvements in mental health outcomes compared to not meeting the recommendation (Rodriguez-Ayllon et al., 2019). The promotion of PA and participation in activities should perhaps be targeted more at the least active children and adolescents with the aim to promote better mental health and wellbeing through school or community-based interventions(McMahon et al., 2017). The inclusion of non-competitive aerobic activities should also be considered in intervention design. In line with the recommendation by Spruit et al. (2016), intervention programmes should be carefully considered and research informed to reduce harmful effect, if the key aim of the intervention is to improve mental health. In a bid to improve the quality and effectiveness of school-based PA programmes, Lubans et al. (2017) provides an evidenced based framework the planning, delivery and evaluation of organized PA sessions in school, community sport and after-school programmes, presenting the principles of Supportive, Active, Autonomous, Fair, Enjoyable (SAAFE). In the future, intervention planners should consult the SAAFE principles at both consultation and strategic stages of planning.

The limitation of this report to provide precise conclusions is due to the diversity of the interventions included in the reviewed papers, the heterogeneity of methodologies, diversity in sample populations and outcome assessment methods. These make it challenging to dissect and identify specific aspects of PA interventions. This limitation is compounded by the range of mental health outcomes explored within the reviews and the lack of high-quality intervention studies.

To conclude, the present report provides support that PA interventions can offer small but useful improvements in mental health outcomes in school-based settings. Evidence suggests that adolescents may benefit more from interventions. Multi-component PA interventions that include a mental health literacy component, delivered in supportive contexts that are positive and reinforcing, should be encouraged to promote benefits of both mental and physical health in children and adolescents.

5. References

Ahn, S., & Fedewa, A. L. (2011). A Meta-analysis of the Relationship Between Children's Physical Activity and Mental Health. *Journal of Pediatric Psychology*, *36*(4), 385-397. https://doi.org/10.1093/jpepsy/jsq107

Andermo, S., Hallgren, M., Nguyen, T.-T.-D., Jonsson, S., Petersen, S., Friberg, M., Romqvist, A., Stubbs, B., & Elinder, L. S. (2020). School-related physical activity interventions and mental health among children: a systematic review and meta-analysis. *Sports Medicine-Open*, *6*(1), Article 25. https://doi.org/10.1186/s40798-020-00254-x

Barrett, P. M., & Pahl, K. M. (2006). School-based intervention: Examining a universal approach to anxiety management. *Journal of Psychologists and Counsellors in Schools*, *16*(1), 55-75.

Biddle, S. J. H., & Asare, M. (2011). Physical activity and mental health in children and adolescents: a review of reviews. *British Journal of Sports Medicine*, *45*(11), 886-895. https://doi.org/10.1136/bjsports-2011-090185

Biddle, S. J. H., Ciaccioni, S., Thomas, G., & Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychology of Sport and Exercise*, *42*, 146-155. https://doi.org/10.1016/j.psychsport.2018.08.011

Brown, H. E., Pearson, N., Braithwaite, R. E., Brown, W. J., & Biddle, S. J. H. (2013). Physical Activity Interventions and Depression in Children and Adolescents A Systematic Review and Meta-Analysis. *Sports Medicine*, *43*(3), 195-206. https://doi.org/10.1007/s40279-012-0015-8

Brunet, J., Sabiston, C. M., Chaiton, M., Barnett, T. A., O'Loughlin, E., Low, N. C. P., & O'Loughlin, J. L. (2013). The association between past and current physical activity and depressive symptoms in young adults: a 10-year prospective study. *Annals of Epidemiology*, *23*(1), 25-30. https://doi.org/https://doi.org/10.1016/j.annepidem.2012.10.006

CMO. (2019). *UK Chief Mediacal Officers' Physical Activity Guidelines*. GOV. UK Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/832868/uk-chief-medical-officers-physical-activity-guidelines.pdf

Costigan, S. A., Eather, N., Plotnikoff, R. C., Hillman, C. H., & Lubans, D. R. (2016). High-Intensity Interval Training for Cognitive and Mental Health in Adolescents. *Med Sci Sports Exerc*, *48*(10), 1985-1993. https://doi.org/10.1249/mss.0000000000000993

Das, J. K., Salam, R. A., Lassi, Z. S., Khan, M. N., Mahmood, W., Patel, V., & Bhutta, Z. A. (2016). Interventions for Adolescent Mental Health: An Overview of Systematic Reviews. *Journal of Adolescent Health*, *59*(4), S49-S60. https://doi.org/10.1016/j.jadohealth.2016.06.020

Eather, N., Morgan, P. J., & Lubans, D. R. (2016). Effects of exercise on mental health outcomes in adolescents: Findings from the CrossFit™ teens randomized controlled trial. *Psychology of Sport and Exercise*, *26*, 14-23.

Girginov, V., Moore, P., Olsen, N., Godfrey, T., & Cooke, F. (2020). Wearable technology-stimulated social interaction for promoting physical activity: A systematic review. *Cogent Social Sciences*, *6*(1), 1742517. https://doi.org/10.1080/23311886.2020.1742517

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1· 9 million participants. *The lancet global health*, *6*(10), e1077-e1086.

Hale, G. E., Colquhoun, L., Lancastle, D., Lewis, N., & Tyson, P. J. (2021). Review: Physical activity interventions for the mental health and well-being of adolescents - a systematic review. *Child Adolesc Ment Health*, *26*(4), 357-368. https://doi.org/10.1111/camh.12485

Jago, R., Salway, R., Emm-Collison, L., Sebire, S. J., Thompson, J. L., & Lawlor, D. A. (2020). Association of BMI category with change in children's physical activity between ages 6 and 11 years: a longitudinal study. *Int J Obes (Lond)*, *44*(1), 104-113. https://doi.org/10.1038/s41366-019-0459-0

James-Palmer, A., Anderson, E. Z., Zucker, L., Kofman, Y., & Daneault, J.-F. (2020). Yoga as an Intervention for the Reduction of Symptoms of Anxiety and Depression in Children and Adolescents: A Systematic Review. *Frontiers in Pediatrics*, *8*, Article 78. https://doi.org/10.3389/fped.2020.00078

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry*, *62*(6), 593-602. https://doi.org/10.1001/archpsyc.62.6.593

Khalsa, S. B., & Butzer, B. (2016). Yoga in school settings: a research review. *Ann N Y Acad Sci*, *1373*(1), 45-55. https://doi.org/10.1111/nyas.13025

Kickbusch, I., Pelikan, J. M., Apfel, F., & Tsouros, A. (2013). *Health literacy*. WHO Regional Office for Europe.

Korczak, D. J., Madigan, S., & Colasanto, M. (2017). Children's physical activity and depression: a meta-analysis. *Pediatrics*, *139*(4).

Leahy, A. A., Mavilidi, M. F., Smith, J. J., Hillman, C. H., Eather, N., Barker, D., & Lubans, D. R. (2020). Review of high-intensity interval training for cognitive and mental health in youth. *Medicine & Science in Sports & Exercise*, *52*(10), 2224-2234.

Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., Kelly, P., Smith, J., Raine, L., & Biddle, S. (2016). Physical Activity for Cognitive and Mental Health in Youth: A Systematic Review of Mechanisms. *Pediatrics*, *138*(3), Article e20161642. https://doi.org/10.1542/peds.2016-1642

Lubans, D. R., Lonsdale, C., Cohen, K., Eather, N., Beauchamp, M. R., Morgan, P. J., Sylvester, B. D., & Smith, J. J. (2017). Framework for the design and delivery of organized physical activity sessions for children and adolescents: rationale and description of the 'SAAFE' teaching principles. *Int J Behav Nutr Phys Act*, *14*(1), 24. https://doi.org/10.1186/s12966-017-0479-x

Marques, A., Henriques-Neto, D., Peralta, M., Martins, J., Demetriou, Y., Schönbach, D. M. I., & Matos, M. G. (2020). Prevalence of Physical Activity among Adolescents from 105 Low, Middle, and High-income Countries. *Int J Environ Res Public Health*, *17*(9). https://doi.org/10.3390/ijerph17093145

McMahon, E. M., Corcoran, P., O'Regan, G., Keeley, H., Cannon, M., Carli, V., Wasserman, C., Hadlaczky, G., Sarchiapone, M., Apter, A., Balazs, J., Balint, M., Bobes, J., Brunner, R., Cozman, D., Haring, C., Iosue, M., Kaess, M., Kahn, J. P., . . . Wasserman, D. (2017). Physical activity in European adolescents and associations with anxiety, depression and well-being. *Eur Child Adolesc Psychiatry*, *26*(1), 111-122. https://doi.org/10.1007/s00787-016-0875-9

Merikangas, K. R., Nakamura, E. F., & Kessler, R. C. (2009). Epidemiology of mental disorders in children and adolescents. *Dialogues Clin Neurosci*, *11*(1), 7-20. https://doi.org/10.31887/DCNS.2009.11.1/krmerikangas

MHF. (2022). Children and Young People: Statistics. https://www.mentalhealth.org.uk/explore-mental-health/statistics/children-young-people-statistics (Mental Health Foundation)

Nature. (2021, 14 October 2021). End the neglect of young people's mental health. *Nature. International Journal of Science*, *859*, 235-236. https://media.nature.com/original/magazine-assets/d41586-021-02690-5/d41586-021-02690-5.pdf

Neil, A. L., & Christensen, H. (2009). Efficacy and effectiveness of school-based prevention and early intervention programs for anxiety. *Clin Psychol Rev*, *29*(3), 208-215. https://doi.org/10.1016/j.cpr.2009.01.002

Neill, R. D., Lloyd, K., Best, P., & Tully, M. A. (2020). The effects of interventions with physical activity components on adolescent mental health: Systematic review and meta-analysis. *Mental Health and Physical Activity*, *19*, Article 100359. https://doi.org/10.1016/j.mhpa.2020.100359

NHS. (2021). Mental Health of Children and Young People in England Survey. *NHS Digital*. https://www.gov.uk/government/statistics/mental-health-of-children-and-young-people-in-england-2021-follow-up-to-the-2017-survey

Ntoumanis, N., Taylor, I. M., & Thøgersen-Ntoumani, C. (2012). A longitudinal examination of coach and peer motivational climates in youth sport: implications for moral attitudes, well-being, and behavioral investment. *Developmental psychology*, *48*(1), 213.

Rafferty, R., Breslin, G., Brennan, D., & Hassan, D. (2016). A systematic review of school-based physical activity interventions on children's wellbeing. *International Review of Sport and Exercise Psychology*, *9*(1), 215-230. https://doi.org/10.1080/1750984x.2016.1164228

Riso, E.-M., Kull, M., & Hannus, A. (2014). OBJECTIVELY MEASURED SCHOOL-BASED PHYSICAL ACTIVITY INTERVENTIONS FOR 6-12-YEAR-OLD CHILDREN IN 2009-2014: A SYSTEMATIC REVIEW. *Acta Kinesiologiae Universitatis Tartuensis*, *20*, 9-24. https://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=114270309&site=ehost-live

Rodriguez-Ayllon, M., Cadenas-Sanchez, C., Estevez-Lopez, F., Munoz, N. E., Mora-Gonzalez, J., Migueles, J. H., Molina-Garcia, P., Henriksson, H., Mena-Molina, A., Martinez-Vizcaino, V., Catena, A., Lof, M., Erickson, K. I., Lubans, D. R., Ortega, F. B., & Esteban-Cornejo, I. (2019). Role of Physical Activity and Sedentary Behavior in the Mental Health of Preschoolers, Children and Adolescents: A Systematic Review and Meta-Analysis. *Sports Medicine*, *49*(9), 1383-1410. https://doi.org/10.1007/s40279-019-01099-5

Rutten, E. A., Stams, G. J. J., Biesta, G. J., Schuengel, C., Dirks, E., & Hoeksma, J. B. (2007). The contribution of organized youth sport to antisocial and prosocial behavior in adolescent athletes. *Journal of youth and adolescence*, *36*(3), 255-264.

Ryan, R. M., & Deci, E. L. (2002). Overview of self-determination theory: An organismic dialectical perspective. *Handbook of self-determination research*, *2*, 3-33.

Schneider, S., Weiss, M., Thiel, A., Werner, A., Mayer, J., Hoffmann, H., & Diehl, K. (2013). Body dissatisfaction in female adolescents: extent and correlates. *Eur J Pediatr*, *172*(3), 373-384. https://doi.org/10.1007/s00431-012-1897-z

Smith, J. J., Beauchamp, M. R., Faulkner, G., Morgan, P. J., Kennedy, S. G., & Lubans, D. R. (2018). Intervention effects and mediators of well-being in a school-based physical activity program for adolescents: The 'Resistance Training for Teens' cluster RCT. *Mental Health and Physical Activity*, *15*, 88-94.

Spruit, A., Assink, M., van Vugt, E., van der Put, C., & Stams, G. J. (2016). The effects of physical activity interventions on psychosocial outcomes in adolescents: A meta-analytic review. *Clinical Psychology Review*, *45*, 56-71. https://doi.org/10.1016/j.cpr.2016.03.006

Torales, J., O'Higgins, M., Castaldelli-Maia, J. M., & Ventriglio, A. (2020). The outbreak of COVID-19 coronavirus and its impact on global mental health. *International Journal of Social Psychiatry*, *66*(4), 317-320. https://doi.org/10.1177/0020764020915212

UNICEF. (2021). *The state of the world's children 2021: On my mind - Promoting, protecting and caring for childrenn's mental health* UNICEF. https://www.unicef.org/media/114636/file/SOWC-2021-full-report-English.pdf

Vaquero-Solis, M., Iglesias Gallego, D., Angel Tapia-Serrano, M., Pulido, J. J., & Antonio Sanchez-Miguel, P. (2020). School-Based Physical Activity Interventions in Children and Adolescents: A Systematic Review. *International Journal of Environmental Research and Public Health*, *17*(3), Article 999. https://doi.org/10.3390/ijerph17030999

Weaver, L. L., & Darragh, A. R. (2015). Systematic Review of Yoga Interventions for Anxiety Reduction Among Children and Adolescents. *The American journal of occupational therapy*, *69*(6), p1-p9. https://doi.org/10.5014/ajot.2015.020115

WHO. (2009). Interventions on diet and physical activity: what works: summary report. . *World Health Organisation*. https://apps.who.int/iris/handle/10665/44140

WHO. (2020). *Physical Activity*. World Health Organisation. https://www.who.int/news-room/fact-sheets/detail/physical-activity

WHO. (2022a). *Mental disorders*. https://www.who.int/news-room/fact-sheets/detail/mental-disorders

WHO. (2022b). Mental health: Strengthening our response. . https://www.who.int/news-room/fact-sheets/detail/mental-health-strengthening-our-response (World Health Organisation)

Yook, Y.-S., Kang, S.-J., & Park, I. (2017). Effects of physical activity intervention combining a new sport and mindfulness yoga on psychological characteristics in adolescents. *International Journal of Sport and Exercise Psychology*, *15*(2), 109-117. https://doi.org/10.1080/1612197X.2015.1069878

Table 1. Review Characteristics and Summary Findings

Author (Date)	**Focus of the review**	**Main outcome variable(s)**	**Characteristics of the interventions** Single component = PA only Multicomponent = PA +	**Articles reviewed**	**Setting(s)**	**Key outcomes and observations**
Andermo et al. (2020)	School-related PA interventions and mental health among children (4-19y)	Positive mental health (defined by well-being, health-related quality of life, happiness, self-esteem, self-confidence, self-compassion, self-efficacy, resilience, positive effect and coping) Internalising mental health problems (defined by emotional problems, worries, anxiety, negative effect and depressive symptoms)	PA only PA +	30	School (School-related or school initiated)	Significant effect of PA for: anxiety (95% CI = 0.072; 0.623, p = 0.013), resilience (95% CI = 0.326; 1.170, p = 0.001), well-being (95% CI = 0.356; 1.398, p = 0.001) composite outcome positive mental health (CI = 0.208; 0.603, p < 0.001)
Rafferty et al. (2016)	School-based PA interventions on children's wellbeing	Physical activity Wellbeing (defined by quality of life; wellness; psychological wellbeing; happiness; life satisfaction; self-esteem; self-concept; body image; physical appearance; anxiety; depression)	PA only (n=3) PA + (n=8)	11	School based	PA: 8/11 interventions reported sig effect on PA Wellbeing: 3/11 interventions reported significant intervention effects on a wellbeing indicator (Global self-worth (obese children only), quality of life, higher levels of autonomy and parent relationships.
Vaquero-Solis et al. (2020)	School-based PA Interventions in Children and	PA Psychosocial variables (Incl. motivational processes, self-esteem, body image, sedentary lifestyle, quality of life)	PA+	41	School-based	10/41 studies (17.1%) revealed sig effects on a range of psychosocial variables (quality of life, body image, self-concept, wellbeing, self-efficacy, appearance, psychological condition, perceived barriers, subjective norms,

	Adolescents (6-18y). Intervention study design; STD, AGT etc.					behavioural perceived control, and prosocial behaviours, and psycho-social climate, fun and boredom reduction)
Brown et al. (2013)	Assess the impact of PA interventions on depression in children and adolescents (5-19y)	Quantitative measures of depression	PA+ Between 9-40weeks	9	School-based and other settings (incl. at risk groups for depression)	Depression - PA intervention effect small but sig (SE = 0.09, 95% CI = −0.43, −0.08, p = 0.004)
Neill et al. (2020)	The effects of interventions with PA components on adolescent mental health (10-19y)	Depression Anxiety Stress	PA and PA+ (educational and counselling) PA included yoga (n = 3), strength, endurance and resistance type exercises (n = 2), aerobic exercises (walking, badminton, climbing, Frisbee, etc.) (n = 4), fitness training (e.g. circuits) (n = 2), dance movement (n = 1) and football (n = 1). Between 4wk-6m	13	School-based and other settings (hospital/clinical setting) and community)	No overall affect.
James-Palmer et al. (2020)	Yoga as an Intervention for the Reduction of Symptoms of Anxiety and	Anxiety (n=10) Depression (n=5) Both (n=12)	PA (Yoga) Duration: Single session -repetitive sessions over 14 weeks	27	School-based (n=13) an other settings incl. hospital/clinical setting (n=2), community	2 (RCTs): sig reductions in symptoms of both anxiety and depression 1 showed sig reductions in symptoms of anxiety The two studies showing improvements across both outcomes

	Depression in Children and Adolescents (3-21y)		Length: 10min – 2h Freq: 1/wk to daily		studio (n=1), orphanage (n=1), summer program (n=2).	compared yoga to no treatment or regular PE class 4/7 studies assessing yoga in a pre-post uncontrolled design showed improvements for both outcomes following the intervention
Rodriguez-Ayllon et al. (2019)	Role of PA and Sedentary Behaviour in the Mental Health of Preschoolers, Children and Adolescents (2-18yrs)	at least one psychological ill-being (i.e. depression, anxiety, stress or negative affect) or psychological well-being (i.e. self-esteem, self-concept, self-efficacy, self-image, positive affect, optimism, happiness and satisfaction with life)	PA Adolescents (n=10) Children (n=8) Did include OW/OB populations (n=4) 8-28 weeks mind-body exercise programs, aerobic exercise programs, resistance exercise programs, combined exercise programs (aerobic + resistance), football, exergames and CrossFit. 60min sessions 2/3 x wk only	114 total: Intervention, cross sectional and longitudinal 18 Intervention.	School-based (n=5) and other settings	Small but significant overall effect of PA on mental health in children and adolescents aged 6–18 years (effect size 0.173, 95% confidence interval 0.106–0.239, $p < 0.001$. Separate analysis for children and adolescents showed effects were significant for adolescents but not for children. Evidence on pre-schoolers was nearly non-existent. Analysis for meeting PA recommendations (< 60 or ≥ 60 min) found programs with ≥ 60 min of exercise activities significantly improved the overall mental health compared with those peers who engaged in an exercise program of < 60 min (ES = 0.277, 95% CI 0.138–0.415; $p < 0.001$, $I2 = 37.22\%$). Secondary analyses showed that exercise improved psychological ill-being (ES = 0.130, 95% CI 0.036–0.224; $p = 0.007$, $I2 = 0\%$) and psychological well-being (ES = 0.189, 95% CI 0.084–0.294; $p < 0.001$, $I2 = 32.3\%$) when they were considered as two independent constructs

Hale et al. (2021)	PA interventions for the mental health and well-being of adolescents (11-19yrs)	Quality of Life (n=7) Self Esteem (n=13) Psychological wellbeing (n=9), ill-being (n=10)	PA+ (Health education sessions, behavioural skills) cardiovascular/aerobic (N = 21) yoga (*N* = 12) resistance training (*N* = 10) Six interventions included team sport Between 7wks-6months Frequency and length of sessions also varied	28 .	School-based (n=16 facilitated by schoolteachers, n=10 by professionals with expertise incl. CrossFit, yoga, sports coaches, taekwondo, exercise psychologists and therapists or researchers	QoL: sig increases only evident in ow/ob or physically inactive adolescents. Well-being effects evident in HIIT – on having greater impact on wellbeing that than aerobics alone. – 20 weeks Yoga – increase in positive affect 12-week intervention
Spruit et al. (2016)	The effects of physical activity interventions on psychosocial outcomes in adolescents (11-18y)	externalizing problems, internalizing problems, self-concept, and academic achievement	Pa and PA+	57	Various	Externalising problems: sig small-to-medium effect (d = 0.320) No moderator effects Internalising: Sig small-to-medium effect (d = 0.316) No moderating effects Self-concept: Sig small-to-medium effect size (d = 0.297). Sig moderating effect of the type of PA (sports vs. exercise) used in the intervention. Larger effects of physical activity interventions on self-concept were found when the intervention consisted of (aerobic) exercise.