Sports Medicine and Health Science 7 (2025) 161–172

Contents lists available at ScienceDirect

Sports Medicine and Health Science

journal homepage: www.keaipublishing.com/smhs

Review

Physical activity, exercise, and mental health of healthy adolescents: A review of the last 5 years

Eva Ruiz-Ranz [a,1], Iván Asín-Izquierdo [b,c,d,1,*]

[a] Department of Education Sciences, Faculty of Medicine and Health Sciences, University of Alcalá, Madrid, Spain
[b] Department of Musical, Plastic and Corporal Expression, Faculty of Social and Human Sciences, University of Zaragoza, Teruel, Spain
[c] Physical Performance and Sports Research Center, Department of Sports and Computer Sciences, Faculty of Sport Sciences, Pablo de Olavide University, Seville, Spain
[d] Department of Biomedical Sciences, Faculty of Medicine and Health Sciences, University of Alcalá, Madrid, Spain

ARTICLE INFO

Keywords:
Sport
Psychology
Youth
Mental wellbeing
Physical exercise intervention

ABSTRACT

The mental health of adolescents is a priority for successful development. Physical activity (PA) and exercise can have effects on the mental health of adolescents. This review analysed the effect that physical exercise interventions can have on the mental health of healthy adolescents between 10 and 19 years of age. The search was carried out in four databases. PubMed, Web of Science, Scopus and SportDiscuss, were searched up to December 31, 2022, following the general model. Eleven studies were selected, with a total sample of 23 681 participants in 2 435 studies published in the last 5 years involving healthy adolescents. The search process and review of the articles was performed by independent expert investigators. The risk-of-bias and the methodological quality were analysed using the Cochrane scale. The limited and heterogeneous studies conducted so far do not clearly establish the benefits of PA on adolescents' mental health. However, some PA interventions seem to improve subjective well-being, self-esteem, physical and mental well-being, anxiety, lifestyle, emotional intelligence, depressive mood, and perceived benefit and confidence in healthy adolescents. It is important to design an effective and appropriate physical exercise programme that can be implemented for adolescents to achieve significant effects on their mental health. Studies that did not implement an appropriate exercise program with improvements in adolescent physical fitness showed no changes in psychological variables. Further research is needed to clearly establish that exercise programmes have positive effects on mental health in healthy adolescents.

1. Introduction

The current definition of health was formulated by the World Health Organisation (WHO) in 1948 and describes health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity".[1] Therefore, as supported by a large number of institutions, there cannot be good health without good mental health.[2,3] The mental health of an individual is the result of a complex process in which various economic, social, biological, political and environmental factors interact to generate the conditions that allow for the full development of human capacities and potentialities. This must be understood from a multidisciplinary perspective, in an inclusive manner without restrictions or cultural limitations.[4–7]

Adolescence is the period of life between childhood and adulthood. This phase of life encompasses elements of biological growth and important social role transitions.[8] The multitude of changes that adolescents experience can lead to significant vulnerability to developing mental health problems.[9] This already worrying situation has been aggravated in recent years by the effects and risks caused by the use of new technologies and physical inactivity,[10] as well as the SARS-CoV-2 pandemic[11]: situations of prolonged isolation, cancellation of sports and activities, distance learning challenges, loneliness, family breakdown and destabilisation, and illness of the adolescent or their family members and even death.[12] In several studies, approximately 30% of parents reported that their children's mental and emotional health had been affected,[13,14] highlighting problems of anxiety and depression,[15] and increased suicidal ideation and behaviour.[16]

The current adolescent mental health landscape was analysed through The State of the World's Children 2021 Report on mental health

* Corresponding author. Department of Musical, Plastic and Corporal Expression, Faculty of Social and Human Sciences, University of Zaragoza, Teruel, Spain.
E-mail addresses: evaruizranz@gmail.com (E. Ruiz-Ranz), iasin@unizar.es, ivanasizq@gmail.com (I. Asín-Izquierdo).
[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.smhs.2024.10.003
Received 29 March 2024; Received in revised form 7 October 2024; Accepted 11 October 2024
Available online 18 October 2024
2666-3376/© 2024 Chengdu Sport University. Publishing services by Elsevier B.V. on behalf of KeAi Communications Co. Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Abbreviations:

5F-Well-Being-AF	Five-Factor Well-Being Scale: Adolescent Form
ALPS	Adolescent Lifestyle Scale
ASK	Active Smarter Kids
BDI	Beck Depression Inventory
BMI	Body Mass Index
BREQ	Behavioural Regulations in Exercise Questionnaire
C-RCT	Cluster-Randomised Controlled Trial
CBTT	Corsi Block Tapping Test
CG	Control Group
COVID-19	SARS-CoV-2 Disease or Coronavirus Disease 2019
DLST	Digit Letter Substitution Test
HIIT	High-Intensity Interval Training
IG	Intervention Group
IPAQ	International Physical Activity Questionnaire
LTEQ	Leisure Time Exercise Questionnaire
PA	Physical Activity
PACER	Progressive Aerobic Cardiovascular and Endurance Run
PAPS	Physical Activity Promotion System
PE	Physical Education
PSDQ	Physical Self-Description Questionnaire
RCT	Randomised Controlled Trials
RSE	Rosenberg Self-Esteem Scale
RSPM	Raven's Standard Progressive Matrices
SAS-A	Social Anxiety Scale for Adolescents
SCWT	Stroop Color and Word Test
SD	Standard Deviation
SDQ	Strengths and Difficulties Questionnaire
SF-12v2	Self-Report Questionnaire
SLCT	Six Letter Cancellation Test
STAI	State-Trait Anxiety Inventory
STAIC	State-Trait Anxiety Inventory for Children
TEIQue-ASF	Trait Emotional Intelligence Questionnaire for Adolescents
TMT	Trail Making Test
WHO	World Health Organisation

in young people.[17] Globally, it is estimated that more than 13% of adolescents aged 10–19 years are living with a WHO-defined mental disorder diagnosis. This represents a staggering 86 million adolescents aged 15–19 and 80 million adolescents aged 10–14. Depression and anxiety comprise 40% of the total of these diagnosed disorders. The others include attention deficit disorder, hyperactivity, conduct disorders, intellectual disability, bipolar disorder, eating disorders, autism, schizophrenia and all clusters of personality disorders. In Europe, 16.3% of 10-19-year-olds have mental health problems, and suicide is one of the leading causes of death among 15–19 year - olds.[17,18]

Physical activity (PA) and exercise appear to have positive outcomes on mental health,[19–24] although wide discrepancies are reported about their effects.[25–29] Studies analysing the effect of PA and exercise programmes on mental health in healthy adolescents typically use interventions based on sports programmes, aerobic training or high-intensity work (e.g. "Tabata", a type of high-intensity interval training and rest) developed in educational institutions. The variables analysed in these types of studies include the effects of PA and exercise programs on subjective well-being, self-esteem, physical and mental well-being, anxiety, lifestyle, emotional intelligence, depressed mood, and perceived benefit and confidence in healthy adolescents (10–19 years old), mainly highlighting mental health and subjective well-being. Furthermore, PA and exercise during the pandemic have shown evidence of positive effects on depression and anxiety,[30] with correlations with mental health. Therefore, they have also been recommended during this period for children and adolescents.[31]

PA and exercise programmes appear to have positive effects on the mental health of healthy adolescents aged 10–19 years, suggesting that these programmes should be promoted among young people as a fundamental element in the care of their mental health, in addition to their physical health. Therefore, the aim of this review was to analyse the existing evidence on the relationship of PA and exercise with mental health in healthy adolescents, through a variety of programmes. This work focuses mainly on the last 5 years where the social context and the COVID-19 (SARS-CoV-2 Disease or Coronavirus Disease 2019) pandemic have required mental health interventions to limit the problems present among adolescents today.

2. Materials and methods

The present study followed the general guidelines for systematic reviews as outlined by established protocols.[32,33]

2.1. Eligibility requirements/criteria

The study was based on articles examining subjects engaged in physical activity (PA) and exercise, and the effects on their mental health. Articles were selected according to the following inclusion criteria: (a) Empirical studies, (b) articles in English or Spanish, (c) published within the last 5 years, (d) studies involving healthy subjects, and (e) adolescents aged 10–19 years. The exclusion criteria were as follows: (a) non-empirical studies, (b) studies that did not focus on the influence of PA and exercise on mental health, (c) participants with severe psychiatric disorders, (d) special populations, (e) individuals with severe pathologies, and (f) studies with samples beyond the established age range.

2.2. Information sources

Studies were sourced from electronic databases including PubMed, SPORTDiscus, Scopus, and Web of Science. The final search was conducted on December 31, 2022, encompassing studies published within the preceding 5 years. This timeframe was chosen to reflect the context of recent years as outlined in the introduction. A snowballing technique was used, based on the references of the selected articles, to identify further relevant studies, adhering to the same eligibility criteria.

2.3. Search strategy

To analyse the influence of PA and exercise on adolescent mental health, combinations of Medical Subject Headings (MESH) terms and commonly used free terms were used, connected by the Boolean operators OR and AND. The specific search strategy was: *(Young people OR teenagers OR adolescents) AND (exercise OR physical activity intervention) AND (Psychology OR Mental health)*.

Studies were filtered by type and limited to those published within the last 5 years. Titles and abstracts were initially reviewed, followed by a full-text review to ensure they met the selection criteria. Finally, the selected articles were organised and assigned identification numbers.

2.4. Selection process

Two researchers independently analysed the studies. Initially, they assessed the citations and abstracts, followed by a full-text analysis. This process ensured that both researchers independently verified that the articles met the established criteria. Agreement was measured using the Cohen kappa coefficient. The resulting concordance was $k = 0.92$. There

was no need to involve a third senior reviewer to resolve any disagreements.

2.5. Data extraction and synthesis

The information was structured by an expert researcher in a database, which recorded date of publication, authors, title, study design, sample size, participant characteristics (gender and age), health status, physical exercise protocol, duration of the intervention, types of measurements and study variables, timing of measurements, and mental health variables analysed. Once structured, the results and findings of the analysed studies were extracted.

2.6. Risk of bias and criteria of methodological quality

The risk of bias and the methodological quality of the included studies were assessed using version 2 of the Cochrane risk of bias tool for randomised trials (RoB 2).[34] Two expert investigators reviewed the studies, resolving any differences through discussion. This process yielded a concordance coefficient of $k = 0.94$.

3. Results

3.1. Study selection

After searching the four databases, a total of 2 435 studies related to the influence of PA on adolescent mental health were found. However, after identifying and deleting duplicates, a total of 1 593 studies remained. After reading and analysing the titles and abstracts, 1 475 were excluded as they did not meet the inclusion-exclusion criteria, leaving a total of 118 articles. Finally, after detailed reading of the articles and analysis of the study methodology, 109 articles were excluded. Of the articles that were included, nine were identified from the pre-established search process.[19–29] A further three articles were identified by other means, such as citation searching through other methods, and a total of two were included.[23,27] Finally, a total of eleven full-text articles involving a total of 23 681 adolescent participants met the inclusion-exclusion criteria and were included in the review. There were seven randomised controlled trials (RCT), one randomised study design, two cluster randomised controlled trials and one controlled study. The selection process is illustrated in a flow chart in Fig. 1 and a summary of the selected studies is shown in Table 1.

3.2. Characteristics of the participants

All participants of the studies in the review were healthy adolescents who were active and free of any diseases. All were high school students, with the exception of the study by Arbinaga et al.,[20] which used undergraduate university students. In nine of the studies the subjects were in the age range of 12–15 years.[19,21–26,28,29] The other two studies were at the borderline of the adolescent period. Resaland et al.[27] used a sample of 10-year-old subjects and Arbinaga et al.[20] used a sample of 19-year-old subjects. In most studies, there was a similar proportion of females and males.[19,21,23,25–29] However, in the studies by Kim and Park[22] and Parajuli et al.[24] the subjects were only female and in the study by Arbinaga et al.,[20] 80% of the participants of the sample were female.

3.3. Duration and protocol of physical activity exposure

The PA programmes or interventions were developed in the participants' secondary schools, with the exception of the study by Arbinaga et al.,[20] in which the students were on average 19 years old, and used university sports facilities. Most of the programmes were developed during PE (Physical Education) classes or in collaboration with this department. However, the study by Ho et al.[21] conducted its programme after school hours, and the study by Arbinaga et al.[20] was conducted outside of the university's pre-established academic timetable. In 8 of the studies reviewed, the duration of the PA intervention was 6–18 weeks.[19–24,26,28] The longest-lasting sports programmes or PA interventions were those of Åvitsland et al.,[25] Resaland et al.[27] and Wassenaar et al.[29] with a duration of 7–10 months.

Regarding the type of programme, three of the studies used a high-intensity exercise programme,[22,26,29] two used an aerobic training programme[20,28] and the remaining six used a general sport programme with

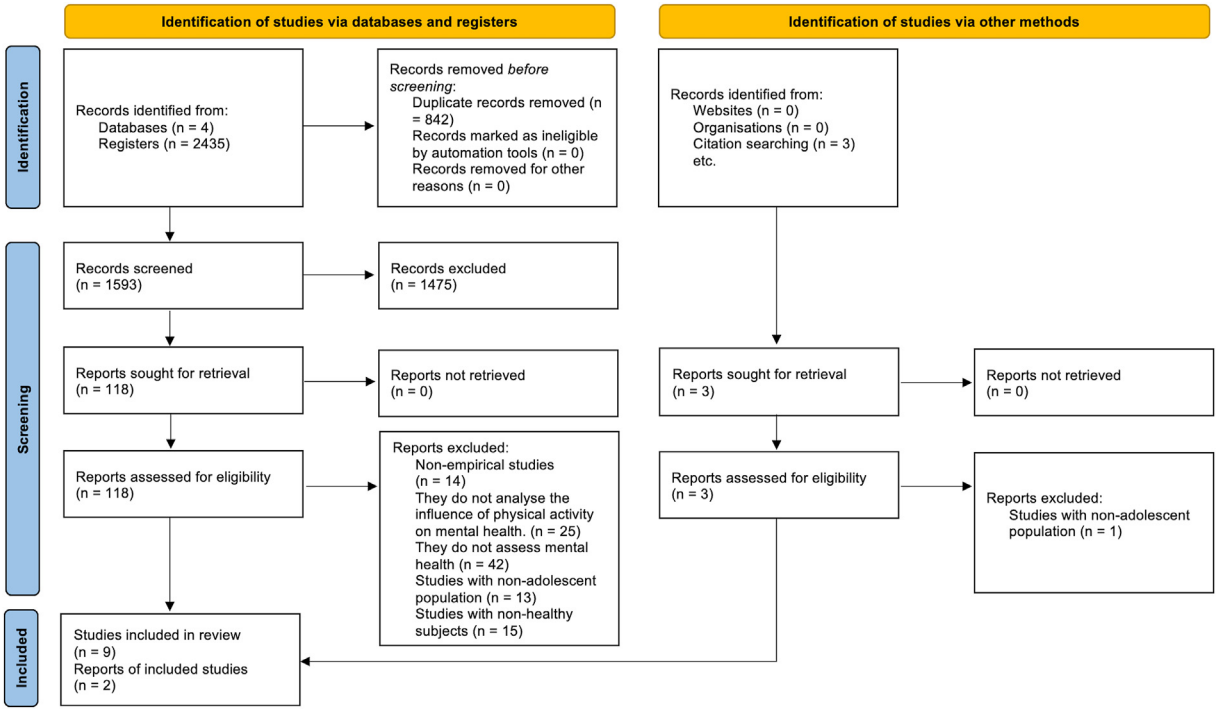

Fig. 1. Flow diagram of the study selection process.

Table 1
Characteristics of the studies included in the review.

Study Study Design	Population recruiting	Type of physical activity		Duration of the intervention	Measuring instruments and variables	Findings
		Intervention Group (IG)	Control Group (CG)			
1. Ho et al. (2017) Randomised controlled trial (RCT)	Adolescents (***n*** = 664, ***n* [IG]** = 333, ***n* [CG]** = 331, **% Women:** 58.1%) **Age:** Mean [*SD*] = 12.3 [±0.76].	After-school sports mentoring programme based on positive youth development (basketball, volleyball and kickboxing).	They received exclusive access to a health education website.	From October 2013 to June 2014, excluding 3 months of school holidays and an exam period. 1 session per week after school for 18 weeks. Each session lasted 90 min.	*Physical and Mental Well-being:* measured by the Chinese version of SF-12v2 (self-report questionnaire). *Physical fitness:* 1 min sit-up test, handgrip, long jump, sit and stretch test, and balance test. *PA levels:* Self-assessed PA Rating Questionnaire for Children and Youth. Body weight and fat ratio: Static stadiometer and body composition monitor. *Developmental assets:* Generalised Self-Efficacy Scale and Connor-Davidson Resilience Scale. *Perceived benefit of the intervention:* 5-point Likert scale, ad hoc.	**Significant differences:** Mental well-being, self-efficacy, resilience, physical fitness, lower limb muscle strength, dynamic balance, PA levels. **Not significant**: Physical well-being, BMI, body fat ratio and social connectedness.
2. Kim & Park (2021) Randomised allocation study	Adolescents (***n*** = 60, ***n* [IG]** = 30, ***n* [CG]** = 30, **% Women:** 100%) **Age:** Mean [*SD*], IG = 14.35 [±0.73] and CG = 14.47 [±0.68].	Tabata exercise programme and psychological modification strategy. A standardised 10 min warm-up was performed consisting of 5 min of slow jogging followed by 5 min of stretching of the main muscle groups at the beginning and then the Tabata exercise (14 min). In total 40 min of work.	Reading a book of free choice for 40 min under the supervision of a co-researcher without any experimental treatment.	12 weeks, physical activity (1×/week, Tabata) and Psychological Modification Strategy (2×/Week).	*Physical Fitness:* Physical Activity Promotion System (PAPS). *Physical Activity Stage:* the PA stage of change scale (questionnaire). *Level of physical activity:* Leisure Time Exercise Questionnaire (LTEQ). *Psychological variables:* applied psychometric instruments, behavioural and cognitive strategies, and exercise self-efficacy questionnaire to measure participants' exercise confidence (5-point Likert scale). *Perceived benefit of the intervention:* decisional balance scale for exercise (5-point Likert scale).	**Significant differences:** Physical activity stage, all psychological variables and increased most of the fitness components of the adolescent girls in the experimental group. **Not significant:** Measurements taken from the control group.
3.Wassenaar et al. (2021) Cluster Randomised Controlled Trial (RCT)	Adolescents from 104 state secondary schools in south/central England (***n*** = 16 017/18 261, ***n* [IG]** = 7 860/9 226, ***n* [CG]** = 8 157/9 035, **% Women:** 55.95%) **Age:** Mean [*SD*], IG = 12.5 [±0.296] and CG = 12.5 [±0.293].	Vigorous HIIT-style PA intervention (4 min as part of a 10 min active warm-up and three 2 min activations per hour), developed together with experts and physical education teachers.	Normal Physical Education classes.	One academic year (10 months: September 2017 to June 2018) taught by physical education teachers during the regular physical education lessons of the year.	*Cardiorespiratory fitness:* 20 m round-trip sprint. *Cognitive performance:* executive functions, relational memory and processing speed, with the JavaScript programme using jsPsych. *Mental health:* Strength and Difficulties Questionnaire (SDQ) and measures of self-esteem with the short version of the Physical Self-Description Questionnaire.	**Significant differences:** - **Not significant:** The effects on cognitive, academic and mental health outcomes are unclear, there are no significant results.
4. Arbinaga et al. (2018) Controlled study	Undergraduate students (***n*** = 66/114, ***n* [IG]** = 53/86 (G2 = 15/28; G3 = 17/29; G4 = 21/29), **n [CG]** = 13/28 (G1 = 13/28), **% Women:** 86.1%) **Age:** Mean [*SD*] = 19.81 [±1.75].	Aerobic training programme. 1.Aerobic exercise only (G2). 2.Aerobic exercise + manipulation of expectations: no psychological change (G3). 3.Aerobic exercise + manipulation of expectations: with psychological effect (G4).	No exercise (G1).	The programme was implemented for a period of seven weeks, 3 days/week (Monday, Tuesday and Thursday), in 70-min sessions, at the University's sports facilities.	*For screening:* ad hoc interview. *Physical activity level:* The International Physical Activity Questionnaire-IPAQ-). *Anxiety:* The State-Trait Anxiety Inventory -STAI-). *Depressed mood:* Beck Depression Inventory, BDI. *BMI:* weight and height measurements. *Psychological assessment:* Rosenberg	**Significant differences:** Participants in the aerobic exercise programmes showed greater increases in fitness, agility and greater improvements in self-esteem and well-being than non-exercisers in the control group. **Not significant:** The data do not support a differential effect of high expectations of psychological benefits on participants' self-esteem

(*continued on next page*)

Table 1 (*continued*)

Study Study Design	Population recruiting	Type of physical activity		Duration of the intervention	Measuring instruments and variables	Findings
		Intervention Group (IG)	Control Group (CG)			
					Self-Esteem Scale (RSE) to assess self-esteem and the Positive Well-Being subscale of the Subjective Exercise Experiences Scale to measure psychological well-being.	or psychological well-being after an aerobic training programme.
5. Åvitsland et al. (2020) Cluster randomised controlled trial (RCT)	Students from 29 lower secondary schools in Norway (***n*** = 2 084, ***n* [IG]** = 1 266 (IG1 = 668; IG2 = 598), ***n* [CG]** = 818, **% Women**: 49.0%) **Age:** 14-15 years.	1.Intervention Model "Active Learning" 30 min of physically active learning, 30 min of PA and a 60 min physical education lesson. 2.Intervention model "Don't worry, be happy". Consisted of a PE lesson and a PA lesson, both focused on facilitating students' interest, responsibility and social relationships.	Non-intervention.	PA at school of 120 min/week, during an intervention period of 29 weeks.	*Mental Health:* Strengths and Difficulties Questionnaire (SDQ). *Physical activity:* with Actigraph accelerometers, models GT3X and GT3X+.	**Significant differences:** - **Not significant:** the two interventions did not improve mental health in the study sample. Results indicated beneficial effects among immigrants and those with mental health problems at baseline. However, the effects could be attributed to a reduction or a prevented increase in conduct, hyperactivity and/or emotional problems.
6. Smith et al. (2018) Randomised controlled trial (RCT)	Adolescents from 16 public coeducational secondary schools (***n*** = 607, ***n* [IG]** = 353, ***n* [CG]** = 254, **% Women**: 49.6%) **Age:** Mean [*SD*] = 14.2 [±0.5].	Resistance training (using body weight exercises and resistance bands) and other "lifelong" health and fitness activities (e.g. yoga, boxing, jumping, circuits). Intervention components: 1 teacher-led introductory seminar for students (30 min) + 1 PA session/ week (90 min) + lunchtime PA sessions 5 sessions/week (20 min) + a smartphone application to complement the face-to-face components during the 10-week intervention. Duration of the intervention, 10 weeks.	Non-intervention.	10 weeks (July to September 2015). Weekly PA sessions (around 90 min) during PE class, PA and sports studies, lunchtime activity sessions (5 × 20 min) and a web-based smartphone app to complement the face-to-face sessions.	*Self-esteem*: 5-item subscale of the short form of the Physical Self-Description Questionnaire (PSDQ). *Subjective well-being*: 7-point Likert scale.	**Significant differences:** - **Not significant:** adolescent resistance training did not have a statistically significant impact on self-esteem and well-being, possibly due to ceiling effects, and this was consistent for several pre-specified subgroups. However, moderating analyses showed that the effects on self-esteem were greater for the subgroup showing some overweight/obesity and resistance training self-efficacy was a significant mediator of changes in self-esteem.
7. Resaland et al. (2019) Randomised controlled trial (RCT)	Students from 57 schools (***n*** = 1 229, ***n* [IG]** = 596 (28 schools), ***n* [CG]** = 533 (29 schools), **% Women**: 47.95%) **Age:** Mean [*SD*] = 10.2 [±0.3].	Active Smarter Kids (ASK). Development: 165 min of extra time (in addition to regular PE, 135 min/ week). Teacher-led PA per week which included: PA lessons in the playground (90 min/week), PA breaks during academic classes (25 min/week) and teacher-developed PA homework (50 min/week).	Content: Physical education prescribed by the curriculum. Duration: 135 minutes/ week.	For seven months (November 2014 to June 2015). Working group 300 min/week and control group 135 min/ week.	*Health-related quality of life:* assessed by self-report, using the Kidscreen-27 questionnaire (which has five domains: physical well-being, psychological well-being, parental autonomy, social and peer support, and school environment). *Physical activity:* PA during the day and school day was measured using triaxial accelerometers (ActiGraph GT3X+, LLC, Pensacola, Florida, USA).	**Significant differences:** - **Not significant:** no significant between-group effect on psychological well-being.
8. Altunkurek & Bebis (2019) Randomised controlled trial (RCT)	Eighth grade adolescents. (***n*** = 132, ***n* [IG]** = 66 (IG1 = 33; IG2 = 33), ***n* [CG]** = 66, **% Women**: 52.03%) **Age:** 12-15 years.	1.Wellness Coaching Programme Group. Development: 3-part programme PA* (1 session/week, 90 min/day), individual interview (duration and frequency based on individual student needs) and group education (1 session/week, 45-60 min/day). *The first 45 min of PA, including	Non-intervention.	Duration: 12 weeks.	*A demographic information form.* *Five-Factor Well-Being Scale:* Adolescent Form (5F-Well-Being-AF). Adolescent Lifestyle Scale (ALPS) 5-point Likert scale.	**Significant differences:** The wellness coaching programme significantly increased adolescents' wellbeing and improved their healthy lifestyle behaviours. This health education programme can be used in conjunction with health education provided by a public health nurse.

(*continued on next page*)

Table 1 (*continued*)

Study Study Design	Population recruiting	Type of physical activity		Duration of the intervention	Measuring instruments and variables	Findings
		Intervention Group (IG)	Control Group (CG)			
		warm-up and stretching with the whole group, while the second part was dedicated to basketball, volleyball and football activities, according to the preferences of the group (45 min). 2.Health Education Group: group education to students in their own classrooms for 45-60 min once a week. A warm-up game was played in the first 5 min, and the last 10 min were dedicated to questions and discussion. The content of the sessions was similar to that of the wellness coaching education.				**Not significant:** -
9. Luna et al. (2019) Randomised controlled trial	Students. (***n*** = 113, ***n* [IG]** = 69, ***n* [CG]** = 44, **% Women**: 43%) **Age:** 12-15 years, Mean [*SD*] 13.82 [±0.79].	Pilot physical-sports education programme based on a sports education model, which included the practice of a sport called Ringo.	A traditional model of PE, based on the analysis and practice of technical skills (didactic unit of traditional collective sport with a conventional teaching style).	Duration: 2 to 3 sessions per week for 6 weeks (55 min each session).	*Health-related quality of life and subjective well-being*: the Kidscreen-10 index. *Participants' positive and negative affect:* Positive and Negative Affect Checklist. Three-choice scale. *Emotional intelligence:* Trait Emotional Intelligence Questionnaire for Adolescents (TEIQue-ASF) 7-point Likert scale. *Anxiety:* Social Anxiety Scale for Adolescents (SAS-A).	**Significant differences:** The pilot physical-sports education programme promoted significant improvements in a specific indicator of subjective well-being and emotional intelligence trait in the experimental group, aspects that are correlated with mental health in adolescents. specific indicator of subjective well-being and trait emotional intelligence in the experimental group, aspects that are correlated with mental health in adolescents. **Not significant:** -
10. Harris et al. (2022) Cluster-randomised controlled trial (C-RCT)	Students from 8 schools. (***n*** = 368, ***n* [IG]** = 182, ***n* [CG]** = 186, **% Women:** 50%) **Age:** 11-13 years, Mean [*SD*] 12.2 [±0.6].	High-intensity interval training (HIIT), 30 s of high effort exercise (attempting to reach at least 90% of maximum effort based on estimated heart rate maximum) based on a relevant high effort component of the narrative such as a 'chase', followed by 30 s of passive recovery, repeated 10 times consecutively.	Usual practice PE delivery using the standard New Zealand curriculum.	Duration: The number of sessions delivered by teachers overall was 19.9 ± 7.6 (mean ± *SD*) for 16 weeks.	*Mental health:* Strength and Difficulties Questionnaire (SDQ). *Mental wellbeing*: Warwick-Edinburgh Mental Wellbeing Scale. *Executive function:* Trail Making Test (TMT). *Self-efficacy for HIIT:* High-Intensity Interval Training Self-Efficacy Questionnaire. *Autonomous motivation for physical activity:* Behavioural Regulations in Exercise Questionnaire (BREQ). *Physical activity:* Cardiorespiratory (aerobic) fitness, Progressive Aerobic Cardiovascular Endurance Run (PACER), the validated Resistance Training Skills Battery. *Maturity offset:* Body mass, stature, seated stature.	**Significant differences:** Physical fitness component improvements were generally greater for the HIIT group, and TMT scores improved significantly in both groups. **Not significant:** It was no improvement of SDQ scores or mental wellbeing in either condition.
11.Parajuli et al. (2022) Randomized	Female students. (***n*** = 89, ***n* [IG, yoga]** = 45, ***n* [CG, physical exercise]** = 44,	Yoga practice comprises breathing exercises, asana (yogic postures), pranayama (yogic breathing exercises), and dhyana (meditation).	Physical exercise includes jogging, stretching, and joint loosening exercises as well as outdoor games.	Duration: the intervention group underwent 1-h group yoga training four days a week for two months.	*The abstract reasoning of teens:* Raven's standard progressive matrices (RSPM). *The working memory of adolescents:* Corsi Block Tapping Test (CBTT).	**Significant differences:** Results showed that yoga improved cognitive function, mental health and academic performance in

(*continued on next page*)

Table 1 (*continued*)

Study Study Design	Population recruiting	Type of physical activity		Duration of the intervention	Measuring instruments and variables	Findings
		Intervention Group (IG)	Control Group (CG)			
control trial (RCT)	**% Women:** 100%) **Age:** 12-14 years, Mean [*SD*] = 12.78 [±0.73].	Yoga was taught by a yoga therapist who has completed graduation in yoga therapy.		The active control group was given 1-h group physical exercise four days a week for two months by the school physical training teacher.	<u>*Selective and focused attention, cognitive and mental flexibility*</u>: Six Letter Cancellation Test (SLCT) and Digit Letter Substitution Test (DLST), Stroop Color and Word Test (SCWT). <u>*Anxiety*</u>: State-Trait Anxiety Inventory for Children (STAIC).	school-aged adolescents. Similarly, physical exercise was also found to be improving working memory, sustained attention, and reduce trait anxiety. The findings indicated that yoga was more effective compared to physical exercise regarding students' fluid intelligence and executive function. <u>**Not significant:**</u> -

Notes. Abbreviations: ALPS: Adolescent Lifestyle Scale; ASK: Active Smarter Kids; BMI: Body Mass Index; BDI: Beck Depression Inventory; BREQ: Behavioural Regulations in Exercise Questionnaire; CBTT: Corsi Block Tapping Test; CG: Control Group; C-RCT: Cluster-Randomised Controlled Trial; DLST: Digit Letter Substitution Test; HIIT: High-Intensity Interval Training; IG: Intervention Group; IPAQ: International Physical Activity Questionnaire; LTEQ: Leisure Time Exercise Questionnaire; PA: Physical Activity; PACER: Progressive Aerobic Cardiovascular Endurance Run; PAPS: Physical Activity Promotion System; PE: Physical Education; PSDQ: Physical Self-Description Questionnaire; RCT: Randomised Controlled Trial; RSE: Rosenberg Self-Esteem Scale; RSPM: Raven's Standard Progressive Matrices; SAS-A: Social Anxiety Scale for Adolescents; SCWT: Stroop Color and Word Test; *SD*: Standard Deviation; SDQ: Strength and Difficulties Questionnaire; SF-12v2: Self-Report Questionnaire; SLCT: Six Letter Cancellation Test; STAI: State-Trait Anxiety Inventory; STAIC: State-Trait Anxiety Inventory for Children; TEIQue-ASF: Trait Emotional Intelligence Questionnaire for Adolescents; TMT: Trail Making Test; 5F-Well-Being-AF: Five-Factor Well-Being Scale: Adolescent Form; h: hours; min: minutes; s: seconds; *n*: numbers

different objectives in sport, psychological, health and social aspects through PA.[19,23–25,27] In terms of session length, five of the studies took place during PE classes of 40–55 minutes (min)/session, with a minimum of 2 classes/week.[22–24,26,29] Another three, in addition to the PE class, added other complementary physical activities during lunchtime, breaks, playground time or other subject time, with a total of 90–135 min/-week.[25,27,28] Three other studies conducted work outside PE classes, involving 70–90 min/session.[19–21]

3.4. *Mental health assessment tools and indicators*

The studies analysed used questionnaires, scales and inventories to assess mental health indicators and psychological variables. Two studies assessed the perceived benefit of the intervention based on a 5-point Likert scale.[21,22] Another three studies assessed mental health indicators based on the Strength and Difficulties Questionnaire (SDQ).[25,26,29] Anxiety was assessed in the studies by Arbinaga et al.[20] and Parajuli et al.[24] using the State-Trait Anxiety Inventory (STAI) and by Luna et al.,[23] who used a social anxiety scale designed for adolescents. Three studies assessed self-esteem: two of them used the Physical Self-Description Questionnaire (PSDQ),[28,29] and the other used the Rosenberg Self-Esteem Scale (RSE scale).[20] Health-related quality of life was assessed in two studies. Resaland et al.[27] used the Kidscreen-27 questionnaire and Luna et al.[23] used the Kidscreen-10 questionnaire. Subjective well-being was assessed in four studies: Arbinaga et al.[20] used the Positive Well-Being subscale of the Subjective Exercise Experiences Scale; Smith et al.[28] applied a 7-point Likert scale; Altunkurek and Bebis[19] used the Five Factor Well-Being Scale: Adolescent Form (5F-Well-Being-AF); and Luna et al.[23] used a Positive and Negative Affect Checklist. Physical and Mental Well-being was assessed by Ho et al.[21] using the translated Chinese version of SF-12v2 (self-report questionnaire) and by Harris et al.[26] with the Warwick-Edinburgh Mental Well-being Scale, a 7-item questionnaire. To measure participants' confidence to perform PA, Kim and Park[22] used the Exercise Self-Efficacy Questionnaire with a 5-point Likert Scale. Depressed mood was only assessed in the study by Arbinaga et al.[20] using the Beck Depression Inventory, BDI. Altunkurek and Bebis[19] were the only ones to assess the Adolescent Lifestyle Scale (ALPS), using a 5-point Likert Scale. Finally, Luna et al.[23] assessed the emotional intelligence of the subjects, with the Trait Emotional Intelligence for Adolescents questionnaire.

3.5. *Relevant psychological measures*

3.5.1. *Subjective well-being*

Four studies measured perceived subjective well-being before and after the PA programme or intervention. In three of the four studies, participants' subjective well-being increased significantly after the PA programme compared to the control group.[19,20,23] In contrast, in the study by Smith et al.,[28] no statistically significant evidence of improvement was found.

3.5.2. *Self-esteem*

Three studies assessed the influence of exercise on adolescents' self-esteem. In two of the studies, no significant differences in this parameter were demonstrated.[28,29] However, Smith et al.,[28] found that self-esteem was significantly higher among overweight/obese adolescents (compared to those who were not overweight), although these effects were also not statistically significant when the subgroups were analysed separately. The study by Arbinaga et al.[20] was the only one to show positive effects on self-esteem; however, the study was the only one in the review that was conducted in a university setting and in late adolescence (19 years of age).

3.5.3. *Anxiety*

Three of the studies in the review assessed anxiety. Two of the studies showed significant differences in this parameter. Arbinaga et al.[20]

assessed generalised anxiety and found significant effects on this variable, while the study by Parajuli et al.[24] also showed positive effects, assessing anxiety in the short and long term; however, the study by Luna et al.,[23] which assessed social anxiety in adolescents, found no significant improvements after the intervention.

3.5.4. Mental health

Mental health was assessed in three studies in the review using the Strength and Difficulties Questionnaire.[25,26,29] None of the studies showed significant improvements in mental health following a PA intervention, although all of them noted lack of data, adherence to and validity of the measures taken as limitations to their studies and findings.

3.5.5. Health-related quality of life

Health-related quality of life was assessed in two studies. After the intervention neither of these two studies showed significant improvements in this variable.[23,27]

3.5.6. Perceived benefit of the intervention

Two studies assessed adolescents' perceived benefit on a 5-point Likert scale, and both studies showed significant improvements after the intervention.[21,22]

3.6. Other psychological variables with significant post-intervention effects

Five studies showed significant improvements in certain psychological parameters assessed after the intervention. Ho et al.[21] found improvements in Physical and Mental Wellbeing, Kim and Park[22] noted improvements in Participants' Confidence to do PA, Arbinaga et al.[20] in Depressed Mood, Altunkurek and Bebis[19] in Adolescent Lifestyle, and Luna et al.[23] in Emotional Intelligence.

3.7. Additional physical activity outcomes

In seven of the studies, in addition to psychological variables, physical variables were also assessed. In six of the studies, possible improvements in the physical fitness of adolescents after PA intervention were assessed. Of these six studies, four showed significant improvements,[20–22,26] and two found no relevant effects on physical fitness.[27,29] In addition, three studies assessed the increase in adolescents' PA level after the intervention. Significant improvements were evident in two of the studies,[21,22] but Åvitsland et al.[25] found no improvements for this parameter.

3.8. Risk of bias article quality

The results of the risk of bias assessment of study quality are presented in Fig. 2. As all studies in the review were randomised studies and the majority were randomised controlled trials (RCTs) (7/11), we used version 2 of the Cochrane risk of bias tool for randomised trials (RoB 2).[34] The tool is structured into five domains through which biases can be introduced into the results. We assessed and analysed, following the detailed guidance and pre-specified algorithms for assessing bias in the different domains of the selected studies. Most of the studies presented a risk of bias with some concerns.[20–22,25–28] There was only one study with a low risk of bias across all domains,[19] and three studies had a high risk of bias.[23,24,29] Although these three studies had a high risk of bias, we

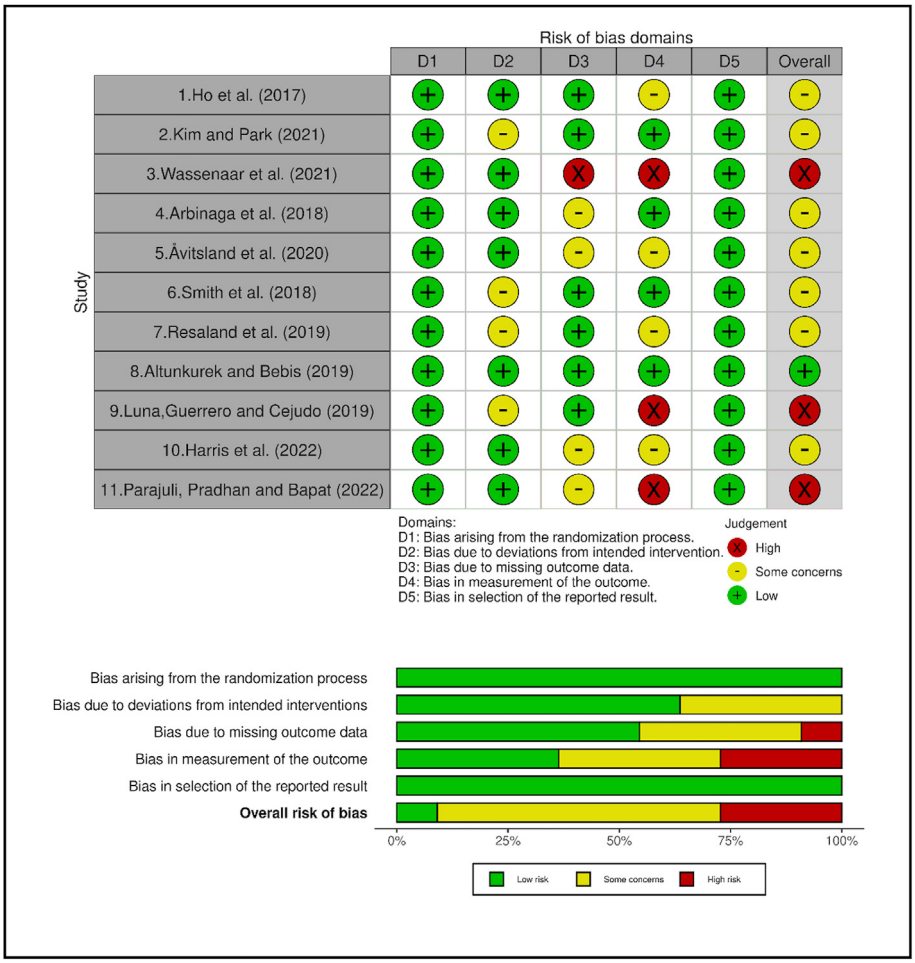

Fig. 2. Summary of risk of bias in the selected studies. Note: The figure presents the process of assessing the risk of bias of the studies in the review.

decided to include them in the review because of the lack of empirical research on the influence of PA on mental health in healthy adolescents, and because of the relevant conclusions they can offer the scientific community.

We reached the following conclusions from the analysis of the studies: all studies in the review had a low risk of bias in the randomisation process, as the allocation sequence was randomised, allocation was concealed from participants, and there were no apparent imbalances between intervention groups. Regarding the effect of intervention allocation or risk of bias due to deviations from the intended interventions, seven studies had low risk[19–21,24–26,29] and four other studies presented some concerns; three of them due to the lack of information provided in algorithm 2.3 on the possible existence of deviations from the intended intervention arising from the study context,[22,23,27] and one in algorithm 2.2 on non-blinding of assessors.[28] Domain 3, representing the risk of bias due to missing outcome data, showed that six studies out of the total had a low risk of bias,[19,21–23,27,28] four had some concerns,[20,24–26] and another[29] exhibited high risk, due to algorithm 3.4, with the possibility that the result was biased by a lack of study data. Domain 4, representing the risk of bias in outcome measurement, showed four studies with low risk,[19,20,22,28] four studies with some concerns due to negative response to algorithm 4.5, with outcome assessment being influenced by the knowledge of the intervention received,[21,25–27] and three studies with high risk due to positive responses to algorithm 4.2, indicating that the measurement or determination of outcome may have differed between intervention groups.[23,24,29] Finally, all studies in the review had a low risk of bias in the assessment of selection bias in the reported outcome, which corresponds to domain 5.

4. Discussion

This review aimed to analyse findings from the last 5 years on the effects of physical exercise interventions on the mental health of healthy adolescents. Eleven studies were included, covering PA interventions including educational programmes, sports activities, aerobic exercise, and high-intensity training. This review updates previous reviews[35–40] and provides additional insights into the psychological benefits of these interventions. However, due to the heterogeneity of the findings, depending on the type, duration and protocol of physical exercise intervention implemented, the results should be interpreted with caution.

The findings suggest that specific PA interventions can significantly improve aspects of mental health, including subjective well-being, self-esteem, and emotional intelligence, all of which are related to neurochemical mechanisms (release of endorphins, serotonin and brain-derived neurotrophic factor (BDNF)). These results align with previous studies, indicating that exercise can foster healthy behaviours and improve the quality of life in adolescents. However, not all studies reported significant improvements, highlighting the need for well-designed interventions tailored to this age group.

The findings suggest that some PA interventions can significantly improve aspects of mental health, including subjective well-being, self-esteem, physical and mental well-being, anxiety, lifestyle, emotional intelligence, depressed mood, and post-intervention confidence and perceived benefit in healthy adolescents (10–19 years).[19–24] The study by Bou-Sospedra et al.[41] also showed that cardiorespiratory fitness and upper limb muscle strength work was positively related to improved self-esteem in adolescents. However, the study by Smouter et al.[42] did not draw any association between PA levels and self-esteem, in line with some of the other studies included in the review.[28,29]

On the other hand, the improvement in the subjective well-being variable, which was one of the main significant findings of the present review,[19,20,23] is also supported by previous studies on well-being coaching and PA, which show positive results for the development of healthy behaviours in adolescents.[43–45] Not only is subjective well-being important; improving the quality and lifestyle of adolescents through exercise is paramount.[46] In some studies, no significant improvements in quality of life were evident.[23,27] This discrepancy may be due to differences in intervention design, duration, and implementation. But other studies, such as that by Calzada-Rodriguez et al.,[47] found a positive average association between PA and physical and mental health-related quality of life in 3 197 children aged 8–14 years, from a range of Spanish schools.

Regarding adolescent lifestyle, in addition to significant improvements in the only study that assessed this parameter in the review,[19] Yavuz and Hacialioglu[48] also showed benefits in adolescents with obesity whose training programme helped them to develop healthy lifestyle behaviours and improve their quality of life. In relation to the positive evidence established in the reviews on PA and anxiety,[20,24] the systematic review by Larun et al.[49] also demonstrated a positive correlation between exercise and the reduction of depression and anxiety scores in the general population of children and adolescents; however, their results are not conclusive, due to the small number of studies selected and found in the scientific literature, as happened with the present review, since the study by Luna et al.[23] also did not show significant improvements in social anxiety in adolescents after an intervention based on physical exercise.

Regarding the assessment of mental health, as measured by the Strength and Difficulties Questionnaire, no significant improvements were observed in the present review,[25,26,29] although Fairclough et al.[50] observed significant improvements in this parameter in 359 participants (aged 9–13 years) who performed light PA and moderate to vigorous PA. Finally, another significant finding of the review was based on the improvements in perceived benefit following exercise-based intervention in adolescents,[21,22] in line with the findings of Doyle et al.[51] that the majority of university students believed that PA could improve well-being, manage depression and anxiety, and perceived it as a positive tool for their mental health.

After secondary analysis of the additional results obtained in the review studies, regarding PA performed by healthy adolescents, it became evident that the review studies that did not show significant improvements in adolescent fitness after PA intervention also did not show significant improvements in psychological variables.[27,29] In contrast, most studies that obtained significant improvements in physical fitness after the intervention also had significant improvements in psychological measures,[20–22] apart from the study by Harris et al.[26] This may indicate that in the studies where no significant effects on mental health in adolescents were shown, the design of the physical exercise programme or intervention was flawed, as there were no improvements in the physical fitness of adolescents, an objective that should be implicit in the design of such programmes, suggesting a problem originating in the design of the intervention itself and the implementation of the exercise programme.

Although this review focused on active and healthy adolescents without clinical diagnoses, there is also a need to present the evidence found in adolescents with some type of psychological pathology, and the influence that PA has on their mental health, due to the large amount of research and findings on this issue.[52–55] Moderate and high PA are inversely associated with anxiety and depressive symptoms in adolescents.[56] Specific studies have shown how PA improves mild to moderate depressive symptoms.[57–59] Aerobic exercise was the main type of exercise for the treatment of adolescents with depression or depressive symptoms, showing a beneficial effect in reducing these symptoms.[60–64] High-intensity exercise was also considered a promising and time-effective exercise-based treatment strategy for depressive symptoms.[65] PA may also be a useful approach to address the symptoms of anxiety in children and youth.[66] Furthermore, in studies by Nia et al.,[67] and Williams and Cash,[68] it was shown that strength training in university students improved their body image and reduced anxiety. Finally, evidence is available to suggest a positive relationship between PA and reduced behavioural and emotional problems, and improved mental health and psychosocial well-being in adolescents with intellectual disabilities.[69]

The PA interventions in all the studies in the review were carried out in schools or universities, showing the importance of promoting sport

and exercise through different strategies or sports programmes within these educational institutions to achieve mental health benefits in adolescents. One strategy could be to implement such exercise programmes through interdisciplinary work between the school's physical education department and health and psychology professionals.

The paucity or absence of studies exploring the effect of management and leadership strategies within schools indicates the need to consider the ways in which educational environments are organised, the culture that is created, and the physical spaces needed to improve mental health in this type of population.[70,71] In addition to strategies in schools and extracurricular or complementary activities, the environment and the role of the family will be essential to increase PA levels and improve mental health in adolescents.[72] School-based PA interventions have also been shown to be effective in improving mental health in low socio-economic groups[73,74] and groups with mental health-related problems.[75]

5. Conclusions

In conclusion, due to the lack of research conducted so far and the large number of heterogeneous findings obtained from studies on the influence of PA on the mental health of healthy adolescents aged 10–19 years, the benefits of PA on their mental health cannot be clearly demonstrated. However, this review concludes that some PA interventions in educational institutions (sports programmes, aerobic training or high intensity work, Tabata), are useful in improving subjective well-being, self-esteem, physical and mental well-being, anxiety, lifestyle, emotional intelligence, depressed mood, and perceived benefit and confidence in healthy adolescents (10–19 years old).

A relevant finding of the study was to highlight the importance of designing an effective, standardised and appropriate physical exercise programme that can be implemented in adolescents to achieve significant effects on their mental health. The review found that studies that did not implement an adequate exercise programme did not have significant improvements in adolescents' physical fitness and, therefore, in psychological variables. Although, so far, the strongest evidence found in the scientific literature supporting the positive effects of PA on the mental health of adolescents seems to be for children and young people diagnosed with depression/depressive symptoms, further research should be conducted on the influence of PA and mental health in healthy adolescents, to develop strategies, recommendations and appropriate sports programmes that ensure good mental health in this type of population.

6. Strengths and limitations

This review has several strengths, including a rigorous methodology as recommended by the general guidelines for reviews to ensure a quality review, a comprehensive literature search of four databases, and adherence to Cochrane guidelines for data extraction and quality assessment. However, it is limited by: (1) the small number of included studies, (2) the variability in interventions and measurement methods used in the studies, which limit the ability to draw meaningful conclusions, (3) the limited scientific literature found on the topic, (4) the inclusion of studies with high risk of bias or with some concerns, (5) the potential exclusion of relevant non-English or non-Spanish articles, and, additionally, (6) the selection and review processes of the articles were conducted by a single observer (two supervisors), which may have introduced bias.

7. Lines of future research

Future studies should focus on standardising physical exercise interventions or programmes to test how these programmes can influence healthy adolescents aged 10–19 years, measuring the same psychological variables and using the same measurement instruments in order to compare the different effects on mental health in this population. It would also be interesting for studies to analyse and correlate the different physical, social and physiological benefits with psychological variables, after different types of physical exercise-based interventions (assessing the volume, intensity and duration of the training programme), to draw more specific and concrete conclusions about the effects of this type of intervention. Likewise, it is important to increase the number of studies that address this topic, at a general level, in order to refute or confirm the conclusions of the present review.

CRediT authorship contribution statement

Eva Ruiz-Ranz: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Iván Asín-Izquierdo:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Data curation, Conceptualization.

Manuscript registration statement

None.

Data sharing statement

Data are available upon reasonable request.

Ethics approval

The research has complied with all the national regulations and has followed the tenets of the Declaration of Helsinki. The project has been developed following the general standards for reviews.

Funding details

The authors have not declared a specific grant for this research. IAI: Call for requalification of the Spanish university system (Margarita Salas Grants) of the Ministry of Universities of the Government of Spain (Funds linked to the European Recovery Instrument of the European Union).

Declaration of competing interest

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

Acknowledge Statement

None.

References

1. World Health Organization. *Constitution of the World Health Organization-Basic Documents, Forty-fifth ed*. Supplement. Geneva, Switzerland: WHO; 2006.
2. Prince M, Patel V, Saxena S, et al. No health without mental health. *Lancet.* 2007; 370(9590):859–877. https://doi.org/10.1016/s0140-6736(07)61238-0.
3. World Health Organization. *Mental Health: Facing the Challenges, Building Solutions Mental Health: Facing the Challenges, Building Solutions*. Copenhagen, Denmark: World Health Organization; 2005.
4. Carrazana V. El concepto de salud mental en psicología humanista-existencial. *Ajayu.* 2003;1(1):1–19.
5. Galderisi S, Heinz A, Kastrup M, Beezhold J, Sartorius N. A proposed new definition of mental health. *Psychiatr Pol.* 2017;51(3):407–411. https://doi.org/10.12740/pp/74145.
6. Macaya-Sandoval XC, Pihan-Vyhmeister R, Vicente-Parada B. Evolution of the mental health construct from a multidisciplinary point of view. *Rev Hum Med.* 2018;18(2): 338–355.
7. World Health Organization. *Promoting Mental Health: Concepts, Emerging Evidence, Practice*. Geneva, Switzerland: World Health Organization; 2005.
8. Sawyer SM, Azzopardi PS, Wickremarathne D, Patton GC. The age of adolescence. *Lancet Child Adolesc Health.* 2018;2(3):223–228. https://doi.org/10.1016/S2352-4642(18)30022-1.
9. Blakemore SJ. Adolescence and mental health. *Lancet.* 2019;393(10185):2030–2031. https://doi.org/10.1016/S0140-6736(19)31013-X.

10. Bhatia R. Effects of the COVID-19 pandemic on child and adolescent mental health. *Curr Opin Psychiatr*. 2020;33(6):568–570. https://doi.org/10.1097/yco.0000000000000651.
11. Palacio-Ortiz JD, Londoño-Herrera JP, Nanclares-Márquez A, Robledo-Rengifo P, Quintero-Cadavid CP. Psychiatric disorders in children and adolescents during the COVID-19 pandemic. *Rev Colomb Psiquiatr*. 2020;49(4):279–288. https://doi.org/10.1016/j.rcp.2020.05.006.
12. Hageman JR. Children's and families' behavioral and mental health during COVID-19. *Pediatr Ann*. 2020;49(10):e405–e406. https://doi.org/10.3928/19382359-20200922-05.
13. Calderon VJ. U.S. parents say COVID-19 harming child's mental health. *Gallup*; 2020. https://news.gallup.com/poll/312605/parents-say-covid-harming-child-mental-health.aspx.
14. Panchal N, Kamal R, Cox C, Garfield R, Chidambaram P. *Mental Health and Substance Use Considerations Among Children during the COVID-19 Pandemic*. KFF; 2021. https://www.kff.org/coronavirus-covid-19/issue-brief/mental-health-and-substance-use-considerations-among-children-during-the-covid-19-pandemic/.
15. C.S. Mott Children's Hospital: Michigan Medicine. *National Poll on Children's Health*. 2021;38(2):1–2. Mott Poll Report: How the pandemic has impacted teen mental health. https://mottpoll.org/reports/how-pandemic-has-impacted-teen-mental-health
16. Thompson EC, Thomas SA, Burke TA, et al. Suicidal thoughts and behaviors in psychiatrically hospitalized adolescents pre- and post- COVID-19: a historical chart review and examination of contextual correlates. *J Affect Disord Rep*. 2021;4(1):100100. https://doi.org/10.1016/j.jadr.2021.100100.
17. UNICEF. *The State of the World's Children 2021: On My Mind, Promoting, Protecting and Caring for Children's Mental Health*. New York, NY: UNICEF; 2022.
18. Navarro-Gómez N. Suicide among young people in Spain: facts and possible causes. An analysis of latest data available. *Clin Salud*. 2017;28(1):25–31. https://doi.org/10.1016/j.clysa.2016.11.002.
19. Altunkurek SZ, Bebis H. The effects of wellness coaching on the wellness and health behaviors of early adolescents. *Publ Health Nurs*. 2019;36(4):488–497. https://doi.org/10.1111/phn.12608.
20. Arbinaga F, Fernández-Ozcorta E, Sáenz-López P, Carmona J. The psychological effects of physical exercise: a controlled study of the placebo effect. *Scand J Psychol*. 2018;59(6):644–652. https://doi.org/10.1111/sjop.12482.
21. Ho FKW, Louie LHT, Wong WH-S, et al. A sports-based youth development program, teen mental health, and physical fitness: an RCT. *Pediatrics*. 2017;140(4):e20171543. https://doi.org/10.1542/peds.2017-1543.
22. Kim Y, Park I. Effects of physical activity and psychological modification-based intervention on physical fitness, physical activity and its related psychological variables in female adolescents. *Int J Environ Res Publ Health*. 2021;18(18):9510. https://doi.org/10.3390/ijerph18189510.
23. Luna P, Guerrero J, Cejudo J. Improving adolescents' subjective well-being, trait emotional intelligence and social anxiety through a programme based on the sport education model. *Int J Environ Res Publ Health*. 2019;16(10):1821. https://doi.org/10.3390/ijerph16101821.
24. Parajuli N, Pradhan B, Bapat S. Effect of yoga on cognitive functions and anxiety among female school children with low academic performance: a randomized control trial. *Compl Ther Clin Pract*. 2022;48(1):101614. https://doi.org/10.1016/j.ctcp.2022.101614.
25. Åvitsland A, Leibinger E, Resaland GK, Solberg RB, Kolle E, Dyrstad SM. Effects of school-based physical activity interventions on mental health in adolescents: the School in Motion cluster randomized controlled trial. *Ment Health Phys Act*. 2020;19(1):100348. https://doi.org/10.1016/j.mhpa.2020.100348.
26. Harris N, Warbrick I, Fleming T, Borotkanics R, Atkins D, Lubans D. Impact of high-intensity interval training including Indigenous narratives on adolescents' mental health: a cluster-randomised controlled trial. *Aust N Z J Publ Health*. 2022;46(6):794–799. https://doi.org/10.1111/1753-6405.13312.
27. Resaland GK, Aadland E, Moe VF, Kolotkin RL, Anderssen SA, Andersen JR. Effects of a physical activity intervention on schoolchildren's health-related quality of life: the active smarter kids (ASK) cluster-randomized controlled trial. *Prev Med Rep*. 2019;13(1):1–4. https://doi.org/10.1016/j.pmedr.2018.11.002.
28. Smith JJ, Beauchamp MR, Faulkner G, Morgan PJ, Kennedy SG, Lubans DR. Intervention effects and mediators of well-being in a school-based physical activity program for adolescents: the 'Resistance Training for Teens' cluster RCT. *Ment Health Phys Act*. 2018;15(1):88–94. https://doi.org/10.1016/j.mhpa.2018.08.002.
29. Wassenaar TM, Wheatley CM, Beale N, et al. The effect of a one-year vigorous physical activity intervention on fitness, cognitive performance and mental health in young adolescents: the Fit to Study cluster randomised controlled trial. *Int J Behav Nutr Phys Activ*. 2021;18(1):47. https://doi.org/10.1186/s12966-021-01113-y.
30. Wolf S, Seiffer B, Zeibig JM, et al. Is physical activity associated with less depression and anxiety during the COVID-19 pandemic? A rapid systematic review. *Sports Med*. 2021;51(8):1771–1783. https://doi.org/10.1007/s40279-021-01468-z.
31. Okuyama J, Seto S, Fukuda Y, et al. Mental health and physical activity among children and adolescents during the COVID-19 pandemic. *Tohoku J Exp Med*. 2021;253(3):203–215. https://doi.org/10.1620/tjem.253.203.
32. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *Ann Intern Med*. 2009;151(4):65–94. https://doi.org/10.7326/0003-4819-151-4-200908180-00136.
33. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372(71):1–9. https://doi.org/10.1136/bmj.n71.
34. Jørgensen L, Paludan-Müller AS, Laursen DRT, et al. Evaluation of the Cochrane tool for assessing risk of bias in randomized clinical trials: overview of published comments and analysis of user practice in Cochrane and non-Cochrane reviews. *Syst Rev*. 2016;5(1):80. https://doi.org/10.1186/s13643-016-0259-8.
35. Andermo S, Hallgren M, Nguyen TTD, et al. School-related physical activity interventions and mental health among children: a systematic review and meta-analysis. *Sports Med Open*. 2020;6(1):25. https://doi.org/10.1186/s40798-020-00254-x.
36. Biddle SJH, Asare M. Physical activity and mental health in children and adolescents: a review of reviews. *Br J Sports Med*. 2011;45(11):886–895. https://doi.org/10.1136/bjsports-2011-090185.
37. Cadenas-Sanchez C, Mena-Molina A, Torres-Lopez LV, et al. Healthier minds in fitter bodies: a systematic review and meta-analysis of the association between physical fitness and mental health in youth. *Sports Med*. 2021;51(12):2571–2605. https://doi.org/10.1007/s40279-021-01520-y.
38. Dale LP, Vanderloo L, Moore S, Faulkner G. Physical activity and depression, anxiety, and self-esteem in children and youth: an umbrella systematic review. *Ment Health Phys Act*. 2019;16(1):66–79. https://doi.org/10.1016/j.mhpa.2018.12.001.
39. Lubans DR, Smith JJ, Morgan PJ, et al. Mediators of psychological well-being in adolescent boys. *J Adolesc Health*. 2016;58(2):230–236. https://doi.org/10.1016/j.jadohealth.2015.10.010.
40. Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, et al. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: a systematic review and meta-analysis. *Sports Med*. 2019;49(9):1383–1410. https://doi.org/10.1007/s40279-019-01099-5.
41. Bou-Sospedra C, Adelantado-Renau M, Beltran-Valls MR, Moliner-Urdiales D. Independent and combined influence of physical fitness components on self-esteem in adolescents: DADOS study. *Ann Hum Biol*. 2021;48(7-8):550–556. https://doi.org/10.1080/03014460.2022.2032337.
42. Smouter L, Coutinho SS, Mascarenhas LPG. Associação entre nível de atividade física e autoconceito de autoestima de adolescentes. *Ciência Saúde Coletiva*. 2019;24(2):455–464. https://doi.org/10.1590/1413-81232018242.34962016.
43. Avery G, Johnson T, Cousins M, Hamilton B. The school wellness nurse: a model for bridging gaps in school wellness programs. *Pediatr Nurs*. 2013;39(1):13–17.
44. Bowe AK, Owens M, Codd MB, Lawlor BA, Glynn RW. Physical activity and mental health in an Irish population. *Ir J Med Sci*. 2019;188(2):625–631. https://doi.org/10.1007/s11845-018-1863-5.
45. Sümen A, Öncel S. Factors that affect healthy lifestyle behaviors of high school students in Turkey: a systematic review. *Eur J Ther*. 2017;23(2):74–82. https://doi.org/10.5152/EurJTher.2017.04044.
46. Marker AM, Steele RG, Noser AE. Physical activity and health-related quality of life in children and adolescents: a systematic review and meta-analysis. *Health Psychol*. 2018;37(10):893–903. https://doi.org/10.1037/hea0000653.
47. Calzada-Rodríguez JI, Denche-Zamorano ÁM, Pérez-Gómez J, et al. Health-related quality of life and frequency of physical activity in Spanish students aged 8-14. *Int J Environ Res Publ Health*. 2021;18(17):9418. https://doi.org/10.3390/ijerph18179418.
48. Yavuz AY, Hacıalioğlu N. The effect of training provided for obese adolescents based on Health Promotion Model on their healthy lifestyle behaviors and life quality. *Prog Nutr*. 2018;20(1):146–160. https://doi.org/10.23751/pn.v20i1.6301.
49. Larun L, Nordheim LV, Ekeland E, Hagen KB, Heian F. Exercise in prevention and treatment of anxiety and depression among children and young people. *Cochrane Database Syst Rev*. 2006;3(1):CD004691. https://doi.org/10.1002/14651858.cd004691.pub2.
50. Fairclough SJ, Tyler R, Dainty JR, et al. Cross-sectional associations between 24-hour activity behaviours and mental health indicators in children and adolescents: a compositional data analysis. *J Sports Sci*. 2021;39(14):1602–1614. https://doi.org/10.1080/02640414.2021.1890351.
51. Doyle CB, Khan A, Burton NW. Knowledge of physical activity guidelines and mental health benefits among Emirati university students. *Perspect Public Health*. 2019;139(6):316–319. https://doi.org/10.1177/1757913919834060.
52. Anthony J, Kinnafick F-E, Papathomas A, Breen K. Physical activity for adolescents with severe mental illness: a systematic scoping review. *Int Rev Sport Exerc Psychol*. 2020;16(1):176–209. https://doi.org/10.1080/1750984x.2020.1833360.
53. Carless D, Douglas K. *The Bristol active life project: physical activity and sport for mental health. En: Sports-Based Health Interventions*. New York, NY: Springer New York; 2016:101–115.
54. Daley AJ. Exercise therapy and mental health in clinical populations: is exercise therapy a worthwhile intervention? *Adv Psychiatr Treat*. 2002;8(4):262–270. https://doi.org/10.1192/apt.8.4.262.
55. Smith PJ, Merwin RM. The role of exercise in management of mental health disorders: an integrative review. *Annu Rev Med*. 2021;72(1):45–62. https://doi.org/10.1146/annurev-med-060619-022943.
56. McDowell CP, MacDonncha C, Herring MP. Brief report: associations of physical activity with anxiety and depression symptoms and status among adolescents. *J Adolesc*. 2017;55(1):1–4. https://doi.org/10.1016/j.adolescence.2016.12.004.
57. Bailey AP, Hetrick SE, Rosenbaum S, Purcell R, Parker AG. Treating depression with physical activity in adolescents and young adults: a systematic review and meta-analysis of randomised controlled trials. *Psychol Med*. 2018;48(7):1068–1083. https://doi.org/10.1017/s0033291717002653.
58. Carter T, Callaghan P, Khalil E, Morres I. The effectiveness of a preferred intensity exercise programme on the mental health outcomes of young people with depression: a sequential mixed methods evaluation. *BMC Publ Health*. 2012;12(1):187. https://doi.org/10.1186/1471-2458-12-187.
59. Nasstasia Y, Baker AL, Lewin TJ, et al. Differential treatment effects of an integrated motivational interviewing and exercise intervention on depressive symptom profiles and associated factors: a randomised controlled cross-over trial among youth with

major depression. *J Affect Disord*. 2019;259(1):413–423. https://doi.org/10.1016/j.jad.2019.08.035.
60. Dabidy-Roshan V, Pourasghar M, Mohammadian Z. The efficacy of intermittent walking in water on the rate of MHPG sulfate and the severity of depression. *Iran J Psychiatry Behav Sci.* 2011;5(2):26–31.
61. Dopp RR, Mooney AJ, Armitage R, King C. Exercise for adolescents with depressive disorders: a feasibility study. *Depress Res Treat*. 2012;257472(1):1–9. https://doi.org/10.1155/2012/257472.
62. Jeong YJ, Hong SC, Lee MS, Park MC, Kim YK, Suh CM. Dance movement therapy improves emotional responses and modulates neurohormones in adolescents with mild depression. *Int J Neurosci*. 2005;115(12):1711–1720. https://doi.org/10.1080/00207450590958574.
63. Mohammadi MF. A study and comparison of the effect of team sports (soccer and volleyball) and individual sports (table tennis and badminton) on depression among high school students. *Aust J Basic Appl Sci.* 2011;5(12):1005–1011.
64. Wang X, Cai ZD, Jiang WT, Fang YY, Sun WX, Wang X. Systematic review and meta-analysis of the effects of exercise on depression in adolescents. *Child Adolesc Psychiatr Ment Health.* 2022;16(1):16. https://doi.org/10.1186/s13034-022-00453-2.
65. Minghetti A, Faude O, Hanssen H, Zahner L, Gerber M, Donath L. Sprint interval training (SIT) substantially reduces depressive symptoms in major depressive disorder (MDD): a randomized controlled trial. *Psychiatr Res*. 2018;265(1):292–297. https://doi.org/10.1016/j.psychres.2018.04.053.
66. Carter T, Pascoe M, Bastounis A, Morres ID, Callaghan P, Parker AG. The effect of physical activity on anxiety in children and young people: a systematic review and meta-analysis. *J Affect Disord*. 2021;285(1):10–21. https://doi.org/10.1016/j.jad.2021.02.026.
67. Rahmani-Nia F, Arazi H, Rahimi R, Piri-Kurd K, Hossaini K. Effects of an eight-week circuit strength training program on the body images and anxiety in untrained college students. *Med dello Sport.* 2011;64(3):297–308.
68. Williams PA, Cash TF. Effects of a circuit weight training program on the body images of college students. *Int J Eat Disord*. 2001;30(1):75–82. https://doi.org/10.1002/eat.1056.
69. Borland RL, Cameron LA, Tonge BJ, Gray KM. Effects of physical activity on behaviour and emotional problems, mental health and psychosocial well-being in children and adolescents with intellectual disability: a systematic review. *J Appl Res Intellect Disabil*. 2022;35(2):399–420. https://doi.org/10.1111/jar.12961.
70. Daly-Smith A, Quarmby T, Archbold VSJ, et al. Using a multi-stakeholder experience-based design process to co-develop the Creating Active Schools Framework. *Int J Behav Nutr Phys Activ*. 2020;17(1):13. https://doi.org/10.1186/s12966-020-0917-z.
71. Troy D, Anderson J, Jessiman PE, et al. What is the impact of structural and cultural factors and interventions within educational settings on promoting positive mental health and preventing poor mental health: a systematic review. *BMC Publ Health*. 2022;22(1):524. https://doi.org/10.1186/s12889-022-12894-7.
72. Rhodes RE, Guerrero MD, Vanderloo LM, et al. Development of a consensus statement on the role of the family in the physical activity, sedentary, and sleep behaviours of children and youth. *Int J Behav Nutr Phys Activ*. 2020;17(1):74. https://doi.org/10.1186/s12966-020-00973-0.
73. Casey MM, Harvey JT, Telford A, Eime RM, Mooney A, Payne WR. Effectiveness of a school-community linked program on physical activity levels and health-related quality of life for adolescent girls. *BMC Publ Health*. 2014;14(1):649. https://doi.org/10.1186/1471-2458-14-649.
74. Lubans D, Richards J, Hillman C, et al. Physical activity for cognitive and mental health in youth: a systematic review of mechanisms. *Pediatrics*. 2016;138(3):e20161642. https://doi.org/10.1542/peds.2016-1642.
75. Eather N, Morgan PJ, Lubans DR. Effects of exercise on mental health outcomes in adolescents: findings from the CrossFitTM teens randomized controlled trial. *Psychol Sport Exerc*. 2016;26(1):14–23. https://doi.org/10.1016/j.psychsport.2016.05.008.