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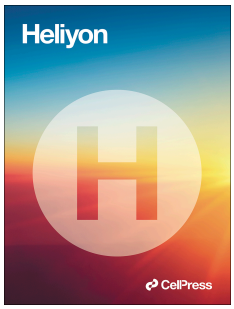

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Serious games to support emotional regulation strategies in educational intervention programs with children and adolescents. Systematic review and meta-analysis

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Abstract

In recent years, there has been an increase in emotional and behavioral disorders in children and adolescents that directly affect their personal, school, family, and social spheres. It has been proposed that serious games designed to train emotional regulation skills can be a more effective, accessible, and attractive alternative for children and adolescents than conventional therapies. However, there is a limited number of studies providing evidence of the effectiveness of these applications. The aim of this review is to analyze the level of effectiveness, feasibility and acceptability of serious games designed to train emotional regulation skills in children and adolescents aged 6 to 18 classified in universal population samples, at risk and diagnosed. A systematic review of papers published between 2008 and 2023 was conducted following the PRISMA statement guidelines. The databases Scopus, Web of Science, PubMed, ERIC, IEEE Xplore, and ACM Digital Library were used. Thirty-three articles were identified that referred to 18 serious games designed to train emotional regulation skills in children and adolescents. All studies used report or self-report measures to code for the recognition of emotions in oneself and the increase or decrease of these emotions. Internal validity was assessed using the Cochrane RoB 2 tool for randomized controlled trials and the ROBINS-I tool for non-randomized studies. A random effects model was implemented, and the effect sizes were calculated as Hedge's g. Although there are limitations in interpreting the results, such as the lack of long-term follow-up, serious game interventions that incorporated biofeedback provided the strongest evidence for generalizability of learned emotion regulation skills to real life. While this does not always imply a clinically significant change, the results show that serious games can be effective, acceptable, and feasible for learning emotional regulation strategies and reducing symptoms related to depression, anxiety, and lack of impulse control.

Keywords: Serious games; Applications in subject areas; Teaching/learning strategies; Improving classroom teaching; Special needs education.

1. Introduction

1.1. Social-emotional issues in children and adolescents

Social-emotional skills are critical to success in school and life in general. However, many of the problems that negatively impact the learning process are mainly explained by difficulties in the social or emotional sphere. In recent years there has been an increase in

emotional disorders in children and adolescents, which also appear at an earlier age and more seriously affect the personal, school, family and social spheres [1, 2]. Between 1990 and 2019 the number of children between 3 and 17 years old diagnosed with depression and anxiety has grown by 27% and 29%, respectively, the number of children between 10 and 14 years old with self-harm has increased by 70%, and suicidal behavior among students in secondary school increased by 44% [2]. In fact, suicide is the second leading cause of death among students from ages 10 to 14 [2]. A much larger proportion of children and adolescents present with subclinical symptoms that cause immediate deterioration, as well as an increased risk of developing disorders later in life. For example, in the year 2021 the prevalence of subclinical anxiety and depression in children and adolescents was estimated at 19% and 38%, respectively [3], with emotional disturbances peaking between 13 and 15 years of age [4,5]. If untreated, the symptoms remain stable over time and in the long term are associated with anxiety or depression disorders, premature school dropout, lower school performance, substance abuse, behavioral problems and suicidal behavior.

The emotional experience of the students influences the classroom climate and, consequently, the coexistence between classmates. The latest reports show that one in four children has suffered bullying and that up to 45% of students can be identified as victims of a violent situation in their school environment [6]. A negative climate of coexistence in the classroom directly affects the student's motivation to participate in the learning process, the perception of the center as threatening and violent, and the development of disorders related to mental health. Many emotional disorders and disruptive behaviors can be attributed to a lack of skills and strategies to manage emotions and solve social problems effectively. Therefore, systematic training of emotional regulation skills could facilitate a significant decrease in this type of disorders and behaviors.

1.2.The use of serious/video games in the field of mental health

Although there are currently emotional regulation programs that are among the best evidence-based practices, data show that between 70% and 80% of children and adolescents with mental health disorders do not benefit from these types of interventions [1] [7]. Possible causes include problems with access to mental health services, long waiting times, the stigma associated with receiving help in mental health-related areas, the high personal and economic cost, and a lack of mental health knowledge [2,8]. Since children and adolescents spend a significant portion of their time in school, integrating mental health resources into school settings could facilitate access to these types of programs. Furthermore, meta-analyses have shown that school-based prevention programs can be less stigmatizing and much more effective than treatment, especially if they are targeted to middle childhood and the preadolescent period, before symptoms peak [1].

Three levels of prevention are frequently distinguished: universal, aimed at all students; selective, aimed at asymptomatic students with risk factors for developing a disorder; and indicated, aimed at students who have been diagnosed. It has been proposed that serious games designed to train emotional regulation skills may provide a more effective alternative to conventional prevention programs at any of the three levels [9]. Mental health game interventions vary in their methodological approach and have been categorized as follows: psychoeducation and cognitive training, virtual reality exposure therapy, exercise, entertainment, games that use/integrate cognitive therapy principles, and biofeedback. Unlike most commercial games designed for entertainment purposes,

serious games for emotion regulation are designed to develop cognitive and emotional skills by practicing coping strategies in a safe and controlled environment. In this study, serious games are considered those that combine the use of empirically validated therapeutic techniques, such as those used in cognitive-behavioral therapy, with the basic characteristics of a video game: having a reward system (incentive and/or objective), being interactive and/or competitive, and having been designed to be fun [10]. These characteristics increase children's motivation to actively participate in interventions and strive to change their behavioral and emotional patterns toward self-directed goals [11]. In this way, serious games engage players in authentically emotional experiences and provide opportunities to practice new regulatory skills until they become automated and can be generalized outside the game.

1.3. Previous studies

The evidence base for the effectiveness of serious games in the field of mental health remains unclear. Torous et al. [12] found that, of 500 apps classified as therapy interventions, less than 1% had been empirically validated. The need to carry out trials that show the effectiveness of video games has been pointed out not only in terms of their short-term benefits, but also in terms of the generalization, maintenance and relevance of the results in the real world. Additionally, this type of intervention must face a difficult challenge: inducing a state of mind that may not be rewarding for the child and creating a context that is attractive, fun and convincing enough for the child to feel motivated to regulate that emotional experience in a timely manner effectively [13]. Without this component, a key justification for using video games as an effective intervention tool would be lost. Therefore, obtaining data on children's participation, acceptance and adherence is essential to guarantee the feasibility and acceptance of video games as an educational technique for emotional regulation.

Yılmaz et al. [14] found that serious games predicted the social problem solving in children between 8 and 14 years old from different cultures, however, they did not evaluate the effect of games on emotional regulation. Villani et al. [15] compared the effect of serious and commercial games on emotional regulation skills. The authors found that commercial games increased enjoyment and mood repair for pleasure-seeking purposes (or stress avoidance). In contrast, interoceptive awareness (awareness of one's internal states) in serious games, measured with both physiological and subjective measures, increased the tendency to actively seek a strategy to reduce negative emotion. Specifically, awareness of negative emotion during gameplay was related to regulation strategies that were more problem-focused than emotion-focused. Although the authors did not include clinical populations or specify the age range. Ferrari et al. [9] conducted a systematic review of digital game interventions for the treatment and promotion of mental health in young people aged 12 to 29 years. However, the authors included a very broad range of terms related to mental health." (e.g., depressive disorders, anxiety disorders, schizophrenia, psychotic disorders, alcohol and substance-related disorders, mood disorders). To analyze the data, the authors merged the mental health conditions into "mild" and "moderate", making it impossible to determine the benefits and limitations of the interventions for specific diagnoses. Garrido et al. [7] conducted a systematic review and meta-analysis of digital mental health interventions and their efficacy in addressing anxiety and depression in young people aged 12 to 25 years. The authors found that the interventions improved symptoms, but the effects only had clinical significance when there was a high level of interaction or therapist supervision. Additionally, the objective outcome was not emotional regulation skills, and the study did

not examine the effect of serious games separately. The results also included other intervention programs that lacked the interactive elements of serious games, such as online programs with psychoeducational materials or videos, or smartphone applications to collect data such as heart rate, physical activity, and other physiological parameters.

Moreover, neuroscience has shown that the development of brain regions involved in the generation and regulation of emotions does not always occur linearly over time, nor does it occur uniformly across multiple brain regions [6]. The early years of adolescence (ages 12 to 14) are characterized by greater emotional reactivity and poorer emotional regulation compared to late adolescence (ages 17 to 18) and adulthood. Related to the above, the developmental trajectories of emotional regulation skills are not equivalently linear. For example, the development of executive function can affect the ability to flexibly switch from one strategy to another in response to changing demands or if the original strategy proves ineffective. Therefore, younger children may have greater difficulty selecting and effectively implementing strategies in real-life situations compared to adolescents. This underscores the importance of studying the effect of serious game interventions across different age groups throughout childhood and adolescence. However, there are few reviews that have studied the effects of serious games on children's emotional regulation skills. Reynard et al. [16] found evidence in favor of studies that had used video games to support the emotional regulation of children and adolescents between 8 and 14 years old. In their review they included samples of children and adolescents with autism spectrum disorders (ASD), finding that in the majority there were problems of feasibility and acceptability. In the same line, Grossard et al. [17] point out the need to adapt these types of interventions to the inter-individual variability of this population and the difficulties that arise from it. Therefore, the results may not be comparable to those found in the population without ASD [18, 19].

1.4. The current study

The following research question was formulated: what does a systematic review and meta-analysis of studies from 2008 to 2023 reveal about the effects of serious games on the emotional regulation skills of children and adolescents aged 6 to 18?

This review aims to complement previous studies by analyzing the level of effectiveness, feasibility and acceptability of serious games designed to train emotional regulation skills in children and adolescents aged 6 to 18 classified in universal population samples, at risk and diagnosed.

The paper is organized as follows: First, the methodological steps carried out are described, such as the search strategy, inclusion and exclusion criteria, selection process, risk of bias assessment, effect measures, and the analysis and synthesis of scientific evidence. Then, the results are presented, detailing the characteristics of the included studies and the main findings. Subsequently, the key findings related to the effectiveness, acceptability, and feasibility of the interventions are discussed, comparing the results with previous studies. Finally, the findings are summarized and recommendations for the field's progression are offered.

2. Method

2.1. Search strategy

The databases Scopus, Web of Science, PubMed, ERIC, IEEE Xplore and ACM Digital Library were used to identify research that was relevant to this review following the guidelines of the PRISMA statement. The last search using databases was carried out in november 2023. The search terms were (video game or serious game or digital game or therapeutic game or online game or mobile device or application) and (child or adolescent or student) and (emotional regulation or emotional management or emotional control or self-control or self-regulation). The syntax, Boolean operators and terms were adapted depending on the database used (Table 1).

Table 1

Database search strings

Database	Search string
Scopus	(TITLE-ABS-KEY("video game" OR "serious game" OR "digital game" OR "therapeutic game" OR "online game" OR "mobile device" OR "application") AND TITLE-ABS-KEY(child* OR adoles* OR student*) AND TITLE-ABS-KEY("emotional regulation" OR "emotional management" OR "emotional control" OR "self-control" OR "self-regulation"))
Web of Science	TS=("video game" OR "serious game" OR "digital game" OR "therapeutic game" OR "online game" OR "mobile device" OR "application") AND TS=(child* OR adoles* OR student*) AND TS=("emotional regulation" OR "emotional management" OR "emotional control" OR "self-control" OR "self-regulation")
PubMed	("video game" OR "serious game" OR "digital game" OR "therapeutic game" OR "online game" OR "mobile device" OR "application") AND (child* OR adoles* OR student*) AND ("emotional regulation" OR "emotional management" OR "emotional control" OR "self-control" OR "self-regulation")
ERIC	("video game" OR "serious game" OR "digital game" OR "therapeutic game" OR "online game" OR "mobile device" OR "application") AND (child* OR adoles* OR student*) AND ("emotional regulation" OR "emotional management" OR "emotional control" OR "self-control" OR "self-regulation")
IEEE Xplore	("video game" OR "serious game" OR "digital game" OR "therapeutic game" OR "online game" OR "mobile device" OR "application") AND (child* OR adoles* OR student*) AND ("emotional regulation" OR "emotional management" OR "emotional control" OR "self-control" OR "self-regulation")
ACM Digital Library	("video game" OR "serious game" OR "digital game" OR "therapeutic game" OR "online game" OR "mobile device" OR "application") AND (child* OR adoles* OR student*) AND ("emotional regulation" OR "emotional management" OR "emotional control" OR "self-control" OR "self-regulation")

2.2. Eligibility criteria

Peer-reviewed research published in journals or conference proceedings whose objective was to demonstrate the effectiveness of video games designed to train emotional regulation skills were included. Studies were selected that provided data for populations between the ages of 6 and 18 years, although a mean age within this restriction was considered eligible. Primary studies were selected, within which all quantitative designs were considered. Interventions that used serious games designed for emotional regulation delivered on any technical platform, including computers, consoles, and mobile devices, were chosen. Those whose primary results referred to

emotional regulation (modulation of positive and/or negative emotions and/or physiological regulation through brain or body signals of these emotions) were included. Studies whose dependent variable had been evaluated using an outcome measure validated by a specialist before and after the intervention were also selected. There was no language restriction. Additionally, studies that met these inclusion criteria and were published after 2008 were considered for inclusion. Studies published after 2008 were included because preliminary scoping searches revealed that digital emotion regulation interventions were developed after 2008.

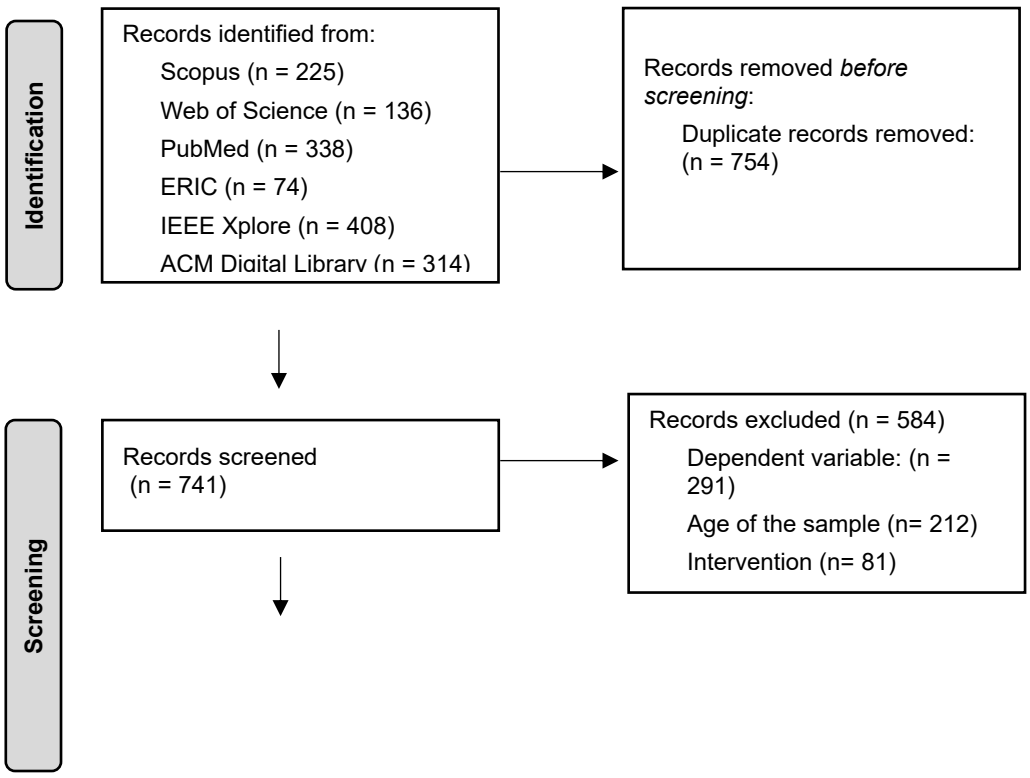
Systematic reviews, meta-analyses, books or book chapters were excluded; interventions whose exclusive objective was a cognitive variable (e.g., understanding of concepts, problem solving, memory); studies with qualitative designs; commercial video games designed exclusively for entertainment purposes; interventions with non-digital games; multimedia programs or applications and digital interventions without game elements, such as virtual reality exposure therapy or computerized cognitive behavioral therapy; studies that only reported acceptability data and did not provide efficacy or feasibility data. Studies carried out with children and adolescents with intellectual disabilities or ASD were also excluded, since the intervention in this case required taking into account many other aspects that were outside the scope of this review [18, 19].

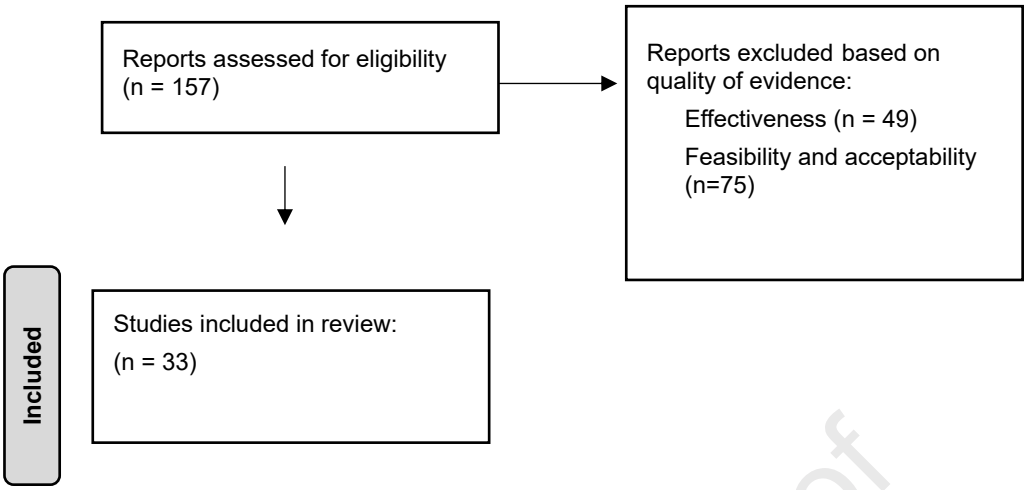
2.3. Selection process

Covidence web-based reference management software was used to record the selection. A total of 1495 results were identified. After eliminating duplicate references, 741 results remained. Two researchers independently selected the articles. A selection of records was carried out through the title and abstract, moving to a full text review when the eligibility criteria could not be obtained through the abstract or the article was considered potentially relevant. A total of 157 articles remained where the methodological quality of the interventions was analyzed. The final selection was made up of 33 articles, 32 of which were written in English and one in Spanish (Figure 1).

Figure 1

Flow diagram of the systematic review process





2.4. Assessment of risk of bias or methodological quality

Evaluation to determine the quality of the interventions in terms of effectiveness was conducted between two researchers using the EPOC data collection form [20]. Each researcher separately extracted data on important methodological characteristics such as: characteristics of the participants (number, age, gender, diagnosis); study design; dependent variables; technical data (compatibility with different operating systems, use of sensors, etc.); evaluation method, context (classroom, home, research center, etc.); evaluation parameters (physiological, behavioral and cognitive measures); effectiveness (effects on at least one dependent variable); generalization (to other contexts and situations); maintenance of effects (over time); feasibility (commitment or degree of involvement or abandonment, implementation of the strategies, adherence, participants' expectations about the effects of the intervention, and transfer to real life); and acceptability (friendliness, fluency or dynamic adaptation to the participant's needs, usability, usefulness, difficulty, attractiveness and relevance). The percentage of times researchers agreed on their assessments was calculated manually. The Interjudge Reliability and Agreement (IRA) was 100%.

To evaluate the internal validity of the randomized controlled trials (RCTs), the Cochrane RoB 2 tool for risk of bias in randomized trials was used [21], for non-randomized studies the ROBINS-I tool was used [22]. The RoB 2 tool provides an overall assessment of each study's protocol, considering factors such as the randomization process, handling of missing or incomplete data, deviations from the intended intervention, blinding of outcomes, and selective outcome reporting. Each criterion is rated as "low risk", "some concerns", or "high risk", leading to an overall bias judgement. The ROBINS-I tool assesses bias based on criteria such as confounding variables, participant selection, intervention classification, deviations from intended interventions for all outcomes, missing data, outcome measurement, and reporting. The final assessment categorizes the studies as having a low, moderate, or high risk of bias.

2.5. Effect measures

To assess the effects of the interventions, the data found in the results section of the analyzed articles were extracted by the researchers and entered into a table. Statistical analysis was performed with Review Manager software version 5.4. Review Manager is a software tool specifically designed for systematic reviews and meta-analyses in the healthcare field, which includes mental health. It is designed to integrate seamlessly with Cochrane's databases and standards, ensuring a high level of quality and consistency in reviews. Additionally, it is a free software that provides advanced tools for meta-analysis, including fixed and random effects models. As heterogeneity between studies was expected to be high, a random effects model was used. This model considers that each study estimates a different, but related, effect size, which follows a distribution (usually normal) around an overall average effect. Therefore, it provides a more accurate and generalizable estimate of the overall effect size by accounting for variability both within and between studies. The effect size of each study was weighted by the inverse of its variance plus the between-study variance, giving more weight to larger studies but also considering the variability between studies. The confidence intervals for the standardized mean differences were 95%. Because this model accounts for between-study variability, the confidence intervals for the overall effect size are typically wider than in a fixed effects model.

The mean and standard deviation (SD) of each study's selected effect were used to calculate Hedges' g and its standard errors (SEs). The effect size was calculated as Hedge's g, as this corrects Cohen's d effect sizes for small sample sizes (across all design types). The results are shown through the p-values and the z-scores. An effect size of 0.2 indicates a small effect, 0.5 indicates a moderate effect, and more than 0.8 a large effect. Furthermore, the heterogeneity of effect sizes across I^2 was considered, considering a threshold of 0% to 25% as low heterogeneity, 26% to 50% as moderate, 51% to 75% as high, and very high for a score greater than 75%.

The effect measures were entered into a table in Covidence and Excel sheet. The effects of the primary outcomes measured in the interventions were coded as emotional regulation when they referred to the recognition of emotions in oneself and the increase or decrease of these emotions. All studies used report or self-report measures, except for one study where the understanding of emotions was indexed by the number of points acquired for correctly identifying functional emotions [44]. Functional emotions are those that facilitate adaptive responses to environmental challenges. In the context of Rational-Emotive Behavior Therapy/Coaching, the identification of these emotions is essential for effective emotion regulation, as they help students to achieve their goals and well-being. To measure the effect in the rest of the interventions, one self-report effect from each included study was selected. When studies provided multiple self-report effects, the constructs of self-report scales or subscales that were most similar across the included studies were selected. For example, most effects measured emotional control; therefore, when possible, effects based on emotional control were selected. The reports or self-reports used to measure emotional regulation were: Emotion Regulation Index for Children and Adolescents (ERICA, Control subscale) [31], Self-Efficacy Questionnaire for Children (SEQ SE, Emotion Self-Efficacy scale) [40], Difficulties in Emotion (DERS, Regulation Scale) [46], Emotional Development Questionnaire (QDE) [26, 45], Skill Acquisition Measure-child version (SAM-C) [52], State and Trait Anger Expression Inventory (STAXI-2, anger-control scale) [27], Visual Analogue Scale (VAS, frustration and relaxed moods) [47, 48] and Calm scale (CS) [29].

The effects of physiological emotional regulation, depression symptoms, and anxiety symptoms were also recorded separately. In cases where studies used multiple measures,

only the primary outcome measure stipulated by the study was extracted and used in the analysis. Physiological regulation symptoms were obtained from brain or body signals associated with emotional regulation and emotional experience. Specifically, heart rate and brain activity measures were collected. For anxiety symptoms, measures obtained through: Spence Children's (SCAS, Anxiety Scale) [5, 13, 39, 41, 49], Strengths and Difficulties Questionnaire –Child Version (SDQ-CE, Emotional Symptoms subscale) [8, 33, 50], Trauma Symptom Checklist for Young Children (TSCA, Anxiety scale) [38], Profile of Affective Distress (PAD, Concern and Anxiety subscale) [32], Screen for Child Anxiety Related Disorders (SCARED) [28], Social Phobia and Anxiety Inventory for Children (SPAI-C) [30], and Multidimensional Anxiety Scale for Children (MASC) [43], were recorded. For depression symptoms, measures collected in: Child Depression Rating Scale-Revised version (CDRS-R) [25, 34, 36, 42], Short Moods and Feelings Questionnaire (SMFQ) [35], The Major Depression Inventory (MDI) [37], Reynolds Adolescent Depression Scale (RADS-2) [4], and Revised Child Anxiety and Depression Scale (RCADS, low mood subscale) [51], were used.

2.6. Analysis and synthesis of scientific evidence

Subsequently, the data on the effectiveness, feasibility and acceptability of serious games were analyzed based on the intervention (technical and design characteristics and theoretical model) and the symptoms and age of the population to which it was directed. Review Manager software was used to analyze the data. Data extracted from RCT and non-RCT studies were analyzed separately. Additionally, non-RCT studies were subdivided into studies based on between-participants comparison designs and repeated measures designs. The effects of group comparison and repeated measures studies (both RCTs and non-RCTs) were assessed through mean changes from baseline to post-intervention assessment. The effect of the play interventions for the RCT group comparisons was determined by the differences in effect sizes between the therapeutic play intervention group and the control groups. Non-inferiority RCTs (which compared the intervention with face-to-face group cognitive behavioral therapy) were included. When studies used multiple comparison groups, data from the active control group were used.

The investigations were coded according to the level of prevention. Children and adolescents with typical development without an identified diagnosis were classified within the universal term; risk to children and adolescents with symptoms of emotional and/or behavioral disorders above the population average without reaching the clinical diagnostic criteria; and diagnosed. Children and adolescents with typical development were identified when the mean and standard deviations of the studied variables were within the range of statistical normality, when the absence of mental disorders was explicitly reported, or when emotional and/or behavioral symptoms above the population or sample mean were not reported. "At-risk" children and adolescents were identified when they scored at or above the 70th percentile, that is, one standard deviation above the mean, within the studied sample or population, on scales that assessed emotional and/or behavioral symptoms. Studies whose samples endorsed any of the risk behaviors from the Youth Risk Behavior Survey (YRBS) questionnaire related to thoughts, plans, and attempts of suicide during the month prior to the first data collection were also included. Finally, children and adolescents diagnosed with an emotional or behavioral disorder were identified when the diagnosis was made by trained clinical professionals with master's and doctoral levels.

Since the largest number of investigations focused on symptoms of anxiety and depression, they were evaluated separately for at-risk and diagnosed populations. In this case, depression and/or anxiety symptoms were used as primary outcomes. In cases where studies used multiple measures of depression and/or anxiety, only the primary outcome measure stipulated by the study was extracted and used in the analysis.

As for the technical characteristics, studies that used biofeedback (to measure peripheral physiological responses such as heart rate, muscle tension, skin conductance, and temperature) or neurofeedback (to measure electrical activity in the brain) devices were analyzed separately from the other studies. The remaining technical characteristics, such as the platform used, the incorporation of RGB-D cameras, or the use of smartphone functionalities (GPS, cameras, sensors, or microphones) are discussed individually for each study. Since the number of studies that used platforms other than PC (such as mobile devices, smartphones, or consoles), smartphone functionalities, or RGB-D cameras was very small, it was not possible to analyze them statistically separately.

The selected studies are based on different theoretical models: cognitive behavioral therapy, mindfulness-based cognitive therapy, neurobehavioral approach, embodied cognition theory, rational emotive behavior therapy, and cognitive behavioral therapy and positive psychology. Each model uses a variety of emotion regulation strategies to modify emotional outcomes, as indicated by experiential, behavioral, and physiological measures. These strategies are related to cognitive-behavioral therapy, such as exposure (gradually facing feared or avoided situations), cognitive restructuring (identifying negative thoughts and replacing them with more realistic and positive ones), mindfulness (to increase awareness and control of present emotions), relaxation techniques, breathing techniques, problem-solving skills, social skills, self-knowledge, behavioral activation (increasing participation in pleasant or meaningful activities), or distraction (diverting attention from negative emotional stimuli). Given that different theoretical models use, interchangeably, the same or different strategies, it was not possible to statistically analyze the studies separately based on the theoretical model or the type of strategy or strategies used. However, these strategies could be encompassed in the extended process model of emotion regulation [23], which considers emotion regulation as a type of valuation and distinguishes four stages of emotion regulation: identification of the need for regulation, selection of a strategy, implementation of the strategy, and success tracking. Therefore, the results are discussed within the framework of the process model, specifying which stage of the process is being described, manipulated, or measured (identification, selection, implementation, or monitoring) and the type of strategy used.

3. Results

In total, 4,337 participants were included, except for the study by Lutz [24] in which the sample number is not reported. Our size ranges from 6 [25] to 903 [26] participants. Three studies do not specify gender [24, 27, 28], among those that do, 49.9% were women, in two studies the sample was exclusively women [4, 29]. 35% of the sample has an average age of between 9 and 10 years and 11 months, 55% has an average age of 11 to 17 years and 6 months, and in the remaining 10% the average could not be found.

Six studies were conducted in the United States [24, 27, 30, 38, 43, 52], six in the Netherlands [4, 5, 13, 39, 40, 41], five in Spain [26, 45 - 48], four in New Zealand [25, 34, 36, 42], four in Romania [31, 32, 33, 44], three in Australia [37, 49, 50], two in the United Kingdom [35, 51], one in Germany , one in Hong Kong , and one in Nepal. 21% of the studies were conducted with populations that could be considered vulnerable due

to belonging to ethnic [25, 34] or sexual minorities [42] or being socially and economically disadvantaged [24, 29, 35, 38].

Of the 33 studies analyzed, 15 were RCTs [4, 5, 13, 30 - 41]. 87% compared the intervention with an active control group [4, 13, 27, 30 - 32, 34, 36, 37, 39 - 41], which could include a different game, the combination of a game and a conventional therapy such as psychoeducational Cognitive-Behavioral Therapy or Rational Emotive Behavioral Education, or exclusively a conventional therapy. 33% of these active control groups used conventional psychoeducational cognitive-behavioral therapy [4, 13, 30, 36, 40]. Of the 33 studies, 42% [4, 5, 13, 24, 25, 29, 36, 37, 39, 41, 42, 44, 49, 50] were conducted longitudinally, with a maximum follow-up period of 12 months.

39% of the studies do not offer data on the acceptability of the intervention, most of them are studies carried out with a universal population (78%). Of the total studies, 16 were implemented at school, 8 in a clinical center, 3 in a research center, 3 at school and at home, and 3 do not indicate the context. Ten studies were carried out with the universal population, 11 with the at-risk population and 12 with the diagnosed population. Within the populations classified as at risk and diagnosed, the majority of studies focused on symptoms of depression (39%) and anxiety (39%), the rest of the studies focused on impulse control deficit (22%). 67% added additional support related to non-digital delivery, support or monitoring, such as classroom sessions, parent training, and tasks with digital journal notes [49], explicit descriptions of emotional regulation strategies through a therapist [31 - 33, 44], classroom lessons [28], monitoring by a Bluetooth-enabled therapist [46 - 48], monitoring and support by a networked therapist [29], practice and documentation of strategies in real life [8, 26, 45], linguistic support [24], and motivation and guidance from researchers [43, 50]. 65% of video games use virtual reality and 39% use neuro or biofeedback. Table 2 details the names of the serious games with some technical characteristics, the theoretical model on which they are based and the objective for which they are designed.

Table 2

Serious game description

Game/Platform(s) /Technical characteristics	**Theoretical model**	**Aim**
MindLight 3D – PC, XBOX Neurofeedback	Cognitive behavioral therapy	Maintaining high β and α below and above threshold, respectively, to navigate scenarios in an old mansion using deep breathing, self-talk, and attentional bias modification. Immersive anxiety induction with guide.
Dojo 3D - PC Biofeedback	Cognitive behavioral therapy	Keep your heart rate below threshold to win mini-games through deep breathing, muscle relaxation, positive thinking, and guided imagery. Immersive fear, frustration and anger induction with character-led tutorials.
Mind-Full 2D - PC Neurofeedback	Cognitive Mindfulness Therapy	Maintain α/θ or β above threshold to control the windlass and glider or build a pile of stones through body relaxation/deep breathing or sustained attention.
The Journey to Wild Divine 3D - PC Biofeedback	Cognitive behavioral therapy	Maintaining heart rate and skin conductance level below threshold using breathing techniques while completing increasingly stressful activities while sailing around an island. Completion of the activity is only possible if the user slows down their breathing and decreases tension upon which they receive immediate feedback.

HeartMath 2D - PC Biofeedback	Cognitive behavioral therapy	Maintain high heart coherence to make the rainbow drop coins into the glass using positive focus and rhythmic breathing.
SAM Software 3D - PC Neurofeedback	Neurobehavioral approach	Self-regulate θ/β or SCP to win games using self-selected cognitive strategies for directing a ball.
RAGE-Control 2D - PC Biofeedback	Cognitive behavioral therapy	Cognitive Behavioral Therapy and Anger Management Therapy Keep heart rate below threshold by deep breathing to ride the spaceship and shoot the aliens.
EEGer4/Zukor Interactive 3D - PC Neurofeedback	Cognitive behavioral therapy	Maintain posterior cue α to earn audiovisual rewards through passive game interaction.
SPARX 3D - PC	Cognitive behavioral therapy	Overcome challenges using strategies such as relaxation, cognitive restructuring, help-seeking, and managing strong emotions through narrative and interaction with characters to rid a virtual fantasy world of sadness and negativity.
REThink 2D - Tablet	Rational emotive behavioral therapy	Know and practice emotional regulation strategies, collecting functional emotions written in balloons and avoiding dysfunctional emotions and other obstacles, to win keys and territories.
GameTeen System 3D - PC, Smartphone, RGB-D	Theory of embodied cognition	Inducing frustration in a game programmed so that users are penalized and receive negative comments or, on the contrary, joy in a game where they are positively reinforced and praised. The subsequent goal is to train breathing strategy with a waving feather.
SmartCAT 2.0 2D – Smartphone GPS	Cognitive behavioral therapy	Interactive mini-games to train coping strategies, problem solving, relaxation and breathing when a virtual trainer detects that a situation may cause anxiety in the user.
Pesky gNATs 3D PC, Smartphone	Cognitive behavioral therapy	Train mindfulness, relaxation, and cognitive restructuring skills through metaphors represented by flies (negative thoughts). An application allows children to transfer what they learn to real life.
Happy 2D - PC	Processual model of emotion	Role playing game. Resolve school and family conflicts in daily life by choosing the correct assertive response from the list.
The Adventures of DoReMiFa 2D - PC	Cognitive behavioral therapy and positive psychology	Modules with characters that represent skills/deficits. Read stories and win challenges by solving problems to find hidden books.
Pegasys 3D - PC	Processual model of emotion	Train and generalize social, conversation and assertiveness skills through interactions with virtual characters from the school, some representing real classmates perceived with anxiety by the children.
Secret Agent Society 3D - PC	Processual model of emotion	Character-driven role-playing game. Recognize and express feelings, complete social problem-solving missions, choose the right emotional regulation strategy to graduate from spy school.

According to the results of the RoB 2 tool, all RCTs were classified as low risk, except for two studies in which data were missing during follow-up [3, 34]. In general, the lowest quality ratings were found in studies carried out with diagnosed populations. The results extracted through the ROBINS-I tool for non-RCT studies show a moderate risk due to the difference in strength or quality with respect to RCTs as described in the Cochrane Guidelines. All non-RCTs presented potential biases in participant selection, although the study by Lucassen et al. [42] makes explicit problems with missing data. Additionally, potential biases were found in the selection of results reported in all non-RCT studies. There were no statistically significant differences between the experimental or control condition before the intervention, except for the study by Knox et al. [43] who found a higher level of anxiety in the control group than in the experimental group at the beginning of the intervention and the study by Kuosmanen et al. [35] who found statistically significant differences between men and women in anxiety, depression and

coping strategies, and mental well-being at the beginning of the study. The heterogeneity of the RCTs was moderate (I^2 = 48%), while it was high for the non-RCTs (I^2 = 69%). When the heterogeneity is analyzed in the trials aimed at the population with anxiety (at risk or diagnosed), the heterogeneity of the RCTs and non-RCTs is moderate (I^2 = 42%), while in the trials aimed at the population with depression it is low (I^2 = 14%).

The results show that 64% of the interventions analyzed significantly improve emotional regulation skills in children and adolescents with a moderate effect size (g = - 0.53; 95% CI: - 1.00 to - 0.09; Z = 2.28, P = 0.02). In the universal population, 60% of interventions show a significant improvement with a moderate effect size (g = - 0.67; 95% CI: - 0.141 to 0.23; Z = 0.35, P = 0. 03), in the at-risk population, 82% of the interventions show a significant improvement with a moderate effect size (g = - 0.64; 95% CI: - 1.88 to 0.80; Z = 0. 42, P = 0.01), and in the diagnosed population 50% of the interventions show a significant improvement with a moderate effect size (g = - 0.52; 95% CI: - 1.14 to 0. 70; Z = 0.59, P = 0.02). 67% of the investigations carried out with samples that presented subclinical or clinical symptoms of anxiety, on the one hand, and depression, on the other, significantly reduced the symptoms with a small effect size (g = - 0.34, CI of 95 %: - 0.72 to 0.37, Z = 0.25, P = 0.04), and moderate (g = - 0.58, 95% CI: - 0.98 to 0.41, Z = 0.32, P = 0.01), respectively.

Tables 3, 4 and 5 contain the following data: authors and year of the study, the sample (number, average age and symptoms and diagnosis when applicable), the type of intervention used (video game and implementation context) and a summary of the results, i.e., results of efficacy, feasibility and acceptability in the universal, at-risk and diagnosed population. These results are discussed in the following section.

Table 3

Effects of serious games on the emotional regulation of the universal population

Author, year	Sample N/Age	Game / Intervention Context	Results Efficacy, feasibility and acceptability
David et al., 2018 [44]	25 13	REThink School	Significant improvement in emotional understanding with a size of moderate effect.
David et al., 2020 [32]	134 12.9	REThink School	Significant reduction in state anxiety and reduction in biological reactivity.
David et al., 2021 [33]	31 12.25	REThink School	Significant improvements in emotional problems, irrational beliefs and negative automatic thoughts, with medium size effect and high levels of satisfaction with the intervention.
Filella et al., 2016 [45]	574 10.5	Happy 8-12 -	Significant improvements in emotional competence and anxiety, with size of the big effect, in group I after the intervention and between groups I/C with a medium effect size. Significant improvement of the environment (playground and classroom), notable increase in academic performance and reduction of conflicts.
Filella et al., 2018 [26]	903 12.6	Happy 12–16 School	Significant difference between I/C group in emotional awareness with size of the small effect, but not in emotional regulation. Statistically significant increase in anxiety levels in group I.

Rodríguez et al., 2015 [46]	52 9-14	GameTeen System C.Research	Significant and positive effect in the effective use of RE strategies. Efficacy was greater for those participants who had more difficulty regulating their emotions.
Schoneveld et al., 2020 [40]	174 9.9	MindLight School	Significant decrease in anxiety symptoms (internalization, externalization and self-efficacy). No significant differences between group I and C in internalization and self-efficacy. CBT was more effective in decreasing externalizing symptoms. No significant differences in effect expectations.
Shum et al., 2019 [28]	332 9.5	The Adventures of DoReMiFa School	There were no significant differences after the intervention, nor between group I and C, in reduction of the rates of anxiety symptoms and negative thoughts. 29.2% dropped out.
Vara et al., 2016 [47]	61 13	GameTeen System School	Arousal increased significantly after the frustration-inducing game and decreased significantly after the breathing RE game (medium to large effect). The RGB-D camera was more fun and realistic but was not helpful in inducing frustration. Greater sympathy for the smartphone and RGB-D camera for induction. Increased usefulness of breathing strategy on smartphone.
Vara et al., 2017 [48]	63 13.6	GameTeen System -	Increased arousal during joy induction and decreased after breathing RE game. Perceived arousal was more intense with the RGB-D camera.

N: sample size; I: intervention; C: control; CBT: cognitive behavioral therapy; RE: emotional regulation

Table 4

Effects of serious games on the emotional regulation of the population at risk

Author, year	**Sample N/Age Symptoms**	**Game / Intervention Context**	**Results Efficacy, feasibility and acceptability**
Antle et al., 2018 [29]	twenty-one 5 – 11 PTSD	Mind-Full School	Significant increase in self-regulation skills (moderate effect). Feelings of calm increased significantly, with a big effect. There were no usability problems. The skills learned transferred to real-world settings (classroom and playground) and remained effective after 2 months. 9% dropped out.
Beaumont et al., 2019 [49]	27 9.8 Anxiety social	Secret Agent Society C.Research	Significant improvements in emotional regulation. A significant effect on parent-reported general anxiety and child-reported social anxiety. All significant treatment effects were maintained at 6-week follow-up.
David et al., 2019 [31]	142 12.9 Depression	REThink School	Significant improvement in emotional awareness and control with a moderate effect size. Significant improvement in emotional symptoms (size of moderate effect) and in depressed mood (large effect size).
Fleming et al., 2012 [34]	32 14-9 Depression	SPARX School	Significant improvement in depression symptoms in group I compared to group C after the intervention and at 10 weeks. Size of the big effect which was maintained until 10 weeks of follow-up. 69%

			completed the entire program. Remission rates were significantly higher in group I (78.9%).
Knox et al., 2011 [43]	24 12.9 Anxiety	The Journey to Wild Divine -	Significant reduction in symptoms of anxiety and depression, somatic/autonomic response and depression, with moderate effect sizes, between group I and C.
Kuosmanen et al., 2017 [35]	66 17.6 Depression Anxiety	SPARX School	Improvement in the use of emotional regulation strategies and significant decrease in expressive suppression (maladaptive strategy). 30% completed the entire program. The majority practiced the skills learned after the intervention. The satisfaction score was 6 out of 10. Half found it useful.
Perry et al., 2017 [37]	540 16.7 Depression	SPARX School	Significant improvement in symptoms of depression and anxiety after intervention with a small to moderate effect size which was maintained at 6 months, but not at 18 months. Need for minimal supervision by teachers. Modest intervention completion rate (59%). Technical problems during implementation.
Poppelaars et al., 2016 [4]	208 13.4 Depression	SPARX School	Depressive symptoms decreased in all conditions (SPARX, CBT, SPARX and CBT, C) and all conditions were equally effective at one-year follow-up. The effect size was medium. Less than half found the game engaging.
Schoneveld et al., 2016 [5]	136 9.9 Anxiety	MindLight School	Improvement in anxiety symptoms without significant differences between group I and C, post-intervention and 3 months later. Significantly higher ratings of anxiety induction on MindLight and attractiveness on Max and the Magic Marker (commercial control game). No significant differences in effect expectations.
Schoneveld et al., 2018 [13]	174 9.9 Anxiety	MindLight School	Significant decrease in anxiety symptoms. No significant differences between group I and C (CBT). Size of small effect to medium in post-test and from medium to large at 3 and 6 months. No significant differences in effect expectations. Moderately fun, low difficulty higher relevance rating in group C (CBT) than group I.
Shepherd et al., 2018 [25]	6 14.7 Depression	SPARX School	Significant improvement in depression symptoms after the intervention with a size of big effect which was maintained after 5 months. It helped to acquire relaxation and cognitive restructuring skills. They found the game useful and attractive.

N: sample size; I: intervention; C: control; PTSD: post-traumatic stress disorder; CBT: cognitive behavioral therapy

Table 5

Effects of serious games on the emotional regulation of the diagnosed population

Author, year	**Sample N/Age Symptoms**	**Game / Intervention Context**	**Results Efficacy, feasibility and acceptability**

Amon and Campbell, 2008 [50]	36 9.1 ADHD	The Journey to Wild Divine C.Research	Significant improvements only in the ADHD group in impulse control, hyperactivity and disruptive behaviors. No improvement after the second month, 25% of group I experienced side effects (more than 66% were taking medications). Both groups found the game difficult, although the difficulty was greater for Group I. Parents in the ADHD group found practicing breathing more beneficial than those in the non-ADHD group.
Beidel et al., 2021 [30]	42 9.6 Anxiety social	Pegasys C.Clinical	After treatment, 60% of the children did not meet the diagnostic criteria. There were significant differences in the indices of anxiety and internalizing and externalizing symptoms with size of the small to moderate effect. Only 1 did not complete the program. Children, parents, and intervention staff rated it as acceptable, feasible, and credible.
Chapman et al., 2016 [51]	eleven 14.7 Depression Anxiety	Pesky gNATs C.Clinical	Half reduced symptoms of anxiety and depression, although the difference was not significant. High level of satisfaction and participation. Adolescents considered it useful for acquiring skills and feeling understood.
Heinrich et al., 2020 [8]	48 9.8 ADHD	SAM Software C.Clinical	Significant improvement in emotional regulation with size of the big effect. Reduction of emotional symptoms in group I. Real-life strategy practice records are not presented.
Kahn et al., 2013 [27]	37 9-17 T.Conduct	RAGE-Control C.Clinical	Significant improvements in anger (state and trait) and heart rate control. High usefulness (Median= 5-6/7).
Lucassen et al., 2015 [42]	twenty-one 16.5 Depression	Rainbow SPARX School and home	Depressive symptoms decreased significantly after the intervention with a large effect size, which was maintained at 3 months of follow-up. Favorable usefulness and satisfaction ratings.
Lutz, 2014 [24]	- - T.Conduct	HeartMath C.Clinical	The majority achieved medium or high coherence in the heart rate variability pattern. It requires inspired clinicians to expand strategies that depend on needs, preferences, and treatment style. Some feasibility and acceptability difficulties were noted, although most requested repeat sessions.
Merry et al., 2012 [36]	187 15.6 Depression	SPARX C.Clinical	Greater reduction in depression symptoms in group I than in group C (usual therapy), not significant. Remission rates were significantly higher in group I (43.7%). The improvements were maintained after 3 months. 62% completed all challenges. The majority showed a high degree of satisfaction and all wished it had lasted the same number of sessions or longer.
Rogel et al., 2020 [38]	32 9.6 PTSD	EEGer4/Zukor Interactive C.Clinical	Significant reduction in anxiety, size of big effect, after treatment in group I, but there were no significant differences between groups I/C after treatment.
Scholten et al., 2016 [39]	138 13.3 Anxiety	Dojo School and home	Improvement in anxiety symptoms without significant differences between group I and C, more pronounced improvement in personalized anxiety in group I evaluated at 3 months. Influence of expectations on results.
Schuurmans et al., 2018 [41]	37 13.9 T.Conduct Anxiety	Dojo School and home	Decreases in self-reported anxiety and externalizing problems, with small to medium effect sizes. The effect on anxiety was maintained at 4 months. High attractiveness, satisfaction, motivation and

			fulfillment. Deep breathing (64.7%) and positive thinking (47.1%) are the most used in daily life.
Silk et al., 2020 [52]	3.4 11.4 Anxiety	SmartCAT 2.0 C.Clinical	Significant improvement in emotional regulation (medium effect size) and significant reduction in anxiety that was maintained at 2 months (effect sizes from large to medium). Satisfaction, feasibility, usability and acceptability were great.

N: sample size; I: intervention; C: control; ADHD: Attention-Deficit/Hyperactivity Disorder; T.Conduct: conduct disorder; PTSD: post-traumatic stress disorder

4. Discussion

This study shows that serious games can be useful tools to train emotional regulation skills in children and adolescents, with moderate significant effects. Serious games have proven to be feasible, acceptable, and effective interventions for all students, including those who belong to populations at higher risk of experiencing mental health difficulties, such as those who are socially and economically disadvantaged [24, 29, 35, 38] or those who belong to ethnic [25, 34] or sexual minorities [42]. These populations not only may have less access to mental health services, but also, when they do, they tend to have a higher dropout rate [1, 35]. The results of this study show that implementing serious games in educational centers could increase adherence and outcomes of mental health programs in an accessible and inclusive way, helping to promote and improve the mental health of all students.

4.1. Serious games as useful tools to train emotional regulation

All interventions focused on the explicit learning of emotional regulation strategies through supportive mediators and the implementation of these strategies in, for the most part, meaningful and attractive contexts. To optimize learning, most of the interventions made use of certain pedagogical techniques. For example, to reduce the cognitive load on working memory they allow the user to control the presentation of novel information by pausing the delivery of the content or by revisiting previous content. Furthermore, each part of the game uses a specific type of emotional strategy, so that they appear separated and organized in a continuum of gradient of difficulty and complexity led by the user. On the other hand, the interfaces are usually simple and intuitive. The user is accompanied by virtual characters who provide key and explicit information on different aspects of the regulation strategies, serving as a guide and support throughout the intervention. These features are essential considering that all the video games analyzed require minimal supervision.

Most of the interventions reviewed are based on the process model of emotion regulation and cognitive behavioral therapy. The processual model proposes that the emotional regulation process occurs in three stages: identification of the emotion, selection of regulation strategy, and implementation. Once the strategy is implemented, the emotional state is re-evaluated and whether it needs to be regulated or not is assessed again; therefore, it is a recursive, continuous and dynamic process. Cognitive behavioral therapy participates in this process by providing strategies to change maladaptive cognitions (such as distorted interpretations) and dysfunctional reactions (such as avoidance) that lead to the development and maintenance of symptoms such as depression or anxiety. Studies using interactive interfaces and bio- or neurofeedback are based on the theory of embodied cognition [46 - 48] and on cognitive neuroscience research on the interaction

between bottom-up emotional processes (perception of internal emotional signals or interoception) and top-down (interpretation and modulation of sensory input) that work together as part of an integrated emotion regulation system [53].

Most video games use virtual environments to simulate real-life situations, providing immersive experiences that allow children to develop and practice coping strategies in a safe and controlled environment. Some authors found that this experience could be intensified by incorporating an RGB-D camera. This device, compared to the computer or smartphone, allowed the interaction to be more realistic and pleasant and increased the feeling of presence, commitment and emotional responses. Furthermore, researchers [46 - 48] found that body movements as an input device allowed children and adolescents to be physically active and control video games in a more intuitive way, which affected the level of participation and the way they got involved in the game. However, instead of inducing frustration, which was the initial objective of the game, it caused a pleasant experience, so the emotional regulation strategies did not have the expected effect. The computer was the least preferred device, however, the smartphone was classified as the most useful for training and transferring the breathing technique to natural contexts. The study by Silk et al. [52] took advantage of smartphone functionalities, such as GPS, cameras, sensors or microphones, to monitor the child's anxiety in real time and notify her when she should put emotional regulation strategies into practice. Studies that have included telephone interventions show that the emotional state improves significantly [7]. This data is important, since the majority of the video games examined are PC applications, while statistics show that children and adolescents spend more time with mobile devices (tablets and smartphones) [7]. Therefore, the implementation of this type of video games on smartphones would help integrate them into the daily routine and promote a feeling of normality.

4.2. Serious games as effective tools in reducing depression symptoms in both the at-risk and diagnosed population

The results show that emotional regulation serious games can be effective in reducing depression symptoms in both the at-risk and diagnosed population. On the other hand, the degree of commitment and satisfaction of the video games that managed to reduce symptoms of depression was high and the abandonment rates were low. In this sense, the most used video game has been SPARX [4, 25, 34 - 37, 42]. In SPARX, an avatar measures the adolescent's emotional state to adapt challenges that must be resolved through positive coping strategies. Additionally, it has a direct teaching component where skills from the fantasy world are applied to real life. Most research with this video game shows clinically significant improvements in depression symptoms, and none shows inferior results to conventional treatment. Although Poppelaars et al. [4] also found these results in the control group that did not receive treatment, the authors argue that in this case the attention and follow-up received by the researchers may have influenced the improvement of symptoms. This is important because, although most adolescents consider privacy and anonymity to be a key benefit of video games, some find it useful to be in contact with professionals [51]. This is an aspect valued in SmartCAT, which allows real-time communication with the therapist, who, in turn, can personalize the material remotely according to the child's emotional experience [52]. Furthermore, it would be interesting to study the interactive and social effect of games, preserving privacy, but integrating chat or online forums, since some adolescents consider it useful to be able to talk about their problems with other peers who experience similar experiences and difficulties [7].

4.3. Serious games as effective tools in reducing anxiety symptoms in universal, at-risk and diagnosed populations

Emotional regulation serious games may also be effective and viable in reducing anxiety symptoms in universal, at-risk and diagnosed populations. In this case, the video game used by the greatest number of investigations has been MindLight [5, 13, 40]. MindLight trains exposure strategies where children or adolescent approach (rather than avoid) situations they find threatening through a variety of relaxation techniques (such as deep breathing or self-talk). Threats become increasingly difficult to avoid and ignore throughout the game, but when players manage to maintain a state of calm for a certain amount of time they are rewarded, allowing the child or adolescent to face their fears gradually and systematically. Additionally, it uses a neurofeeback device to change attention bias, rewarding children for quickly attending to and responding to positive stimuli (e.g., smiling faces) and for neglecting or diverting attention from negative stimuli (e.g., angry faces).

All serious games used to regulate anxiety or impulse control symptoms incorporated bio or neurofeedback. Bio or neurofeedback devices increased the effectiveness of the use of cognitive regulation strategies on improving emotional state. Unlike conventional video games, these devices use biological signals to adjust the game environment, that is, control the speed or adapt the layout. The use of portable neurofeedback devices is feasible in children from the age of five; in addition, there are low-priced devices with easy-to-use interfaces for professionals who do not have prior technical experience [54]. Varying the difficulty of the game in correspondence with the player's emotional variation helps preserve their interest and maintain engagement. Children and adolescents found adaptive neurofeedback games to be motivating, engaging, and more challenging than non-adaptive games [8, 27]. In addition, real-time bio or visual neurofeedback can increase immersion in the game and, as a consequence, engagement. For example, in MindLight, children wear a headset that transforms the raw values of an electroencephalogram (EEG) into gradations of light that shine from the avatar's head. The more relaxed the players are, the brighter the light shines, however, when anxiety increases the light goes out and they are forced to remain calm to see again. Serious games that incorporated bio or neurofeedback provided the greatest evidence of generalization of learned emotional regulation skills, this suggests that it could be one of the most appropriate video game components for the first step of transfer to real life. These serious games not only played a greater role in the process of emotional identification and awareness, but also provided emotional regulation strategies, such as deep breathing, muscle relaxation, and heart rate control. However, the transfer of explicit strategies like cognitive restructuring or reevaluation to reduce negative emotions in daily life situations might be more related to long-term outcomes. According to cognitive-behavioral principles, time and practice are two fundamental factors for changing the dysfunctional schemas that generate and maintain maladaptive cognitions and behaviors. But, the follow-up of results over time is limited or absent in most studies, so no conclusions can be drawn about the sustainability of the effects of interventions in the long term.

4.4. Challenges in designing serious games to train emotional regulation

One of the advantages that video games have over traditional cognitive behavioral therapy is that they tend to focus more on the child “doing” than on providing knowledge about what they “should do”. It has been found that students may consider the educational content of video games boring and tedious, especially when they cannot adapt it to their

needs, that is, skipping something if they already understand it [7]. For example, the video game The Adventures of DoReMiFa [28] used lessons from positive psychology through storytelling to explain concepts about identifying and managing emotional skills and problem-solving activities. The program was implemented with children aged 8 to 12 in 8 lessons of approximately 25 to 60 minutes each. The results showed that improving knowledge about mental health did not lead to a change in behavior or a reduction in symptoms and automatic negative thoughts. Teachers believed that experiential learning might be more suitable for students, so they suggested starting the lesson with activities first and then teaching the concepts, rather than teaching the concepts first and then the activities. Additionally, although some students reported that they had tried to apply the skills taught in their daily lives, the authors suggested that students might not only need additional time to understand the concepts but also to transfer them into practice. This underscores the importance of analyzing the optimal duration of interventions that best benefit students.

Taking advantage of the opportunities offered by video games to put emotional regulation strategies into practice in a playful, attractive and interactive way can increase the hours of training, and, with it, the automation of the strategies. However, the emotional regulation process does not work in the same way in children as in adolescents. Certain strategies require executive and social cognition skills that are more likely to be developed in virtual environments that simulate real-life situations. For example, MindLight is set in a haunted mansion with ghosts. The protagonist's mission is to save her grandmother from the evil forces that have possessed her. Without questioning the authenticity of the emotions, it is unlikely that the child will be able to generalize the learned strategies to situations in her daily life. In fact, Schoneveld et al. [40] verified that, in schoolchildren, the experience of relevance to real life of the game was significantly less than that generated in a group cognitive behavioral therapy, but not less than that obtained in a commercial game that is not therapeutic. This may explain why school-age children, in all populations studied, benefit less from the advantages of MindLight, compared to conventional therapies, than adolescents. In some cases, video games that excessively promote projective fantasy (e.g., role-playing) and immersion (e.g., feeling inside another reality) may act more as an avoidance strategy than as a active coping strategy. These video games can provide a distraction that helps children temporarily escape from stressful or difficult situations, but they do not teach strategies to resolve these situations in the long term. On the contrary, Happy 8-12, a school and family conflict resolution role-playing game based on scenes from daily life, not only showed significant effects on emotion management, but also significantly improved the classroom climate and the academic performance. Similar results were found with Pegasys-VR, which, through a school environment with characters representing real classmates, managed to generalize the trained strategies to the natural context. This suggests that for younger children, it may be important to include explicit training content in emotional regulation games that clearly relates to real-life experiences and difficulties.

Similarly, Filella et al. [26] found that Happy 12-16, the same video game that significantly reduced anxiety symptoms in schoolchildren aged 9 to 11, significantly increased anxiety in a sample of adolescents aged 12 to 13. In the same vein, Chapman et al. [50] investigated whether Pesky gNATs, a video game designed for children aged 9 to 12, was viable and acceptable for adolescents aged 13 to 16, finding that the intervention increased, rather than reduced, anxiety symptoms. Teenagers felt that the game design seemed made for younger users. These results once again reveal the importance of restricting age ranges and adapting the intervention to the differential characteristics of each stage of development. Early adolescence (ages 12 to 14) is characterized by a more

negative average emotional state, hypersensitivity to rejection, stress, and greater emotional reactivity, compared to childhood (up to age 10) and late adolescence (ages 17 to 18). The age range of the students in the studies could also explain the success of the GameTeen System video game in inducing frustration [46, 47] but not joy [48], in adolescents aged 12 to 14.

In general, when the game responds to the interests of the age at which it is aimed and users can identify with the situations or characters with which they interact, the attractiveness of the game increases and, therefore, adherence and participation. For example, in the study by Kuosmanen et al. [35], 70% of adolescents did not complete the entire program and more than 40% admitted to practicing little or no techniques taught in the program. The authors suggested that the content of the game may not be as relevant or significant in samples with mild or moderate symptoms of depression, which could explain why the effect of these interventions is lower in the universal population than in the at-risk or diagnosed population. They also postulated that the cultural differences of the sample (Irish), with respect to those of the country where the game was designed (New Zealand), could have influenced a lower identification with the characters.

On the other hand, it has been found that the use of emotion regulation strategies varies according to culture. People from cultures that value self-reflection and introspection tend to use reappraisal more frequently than average (e.g., Australians), while people from cultures that value the open expression of emotions tend to use suppression less frequently (e.g., Americans) [55]. The sociocultural diversity of student populations presents a challenge in designing serious games and mental health programs that are sensitive to diverse cultural backgrounds. Most of the identified studies have been conducted in a Western context. Future research should consider conducting more studies in an Eastern context. Emotions, expressions, and interpersonal dynamics can have cultural nuances, so the development of cultural competencies is required to avoid unintentional biases or cultural insensitivity. Involving students and experts from diverse cultural backgrounds in the creation of digital emotional regulation games helps ensure that socio-emotional education programs are inclusive, respectful, and reflect cultural diversity both inside and outside the classroom.

5. Conclusions

5.1. An overview of the contributions of the current study

This review contributes to the advancement of serious games designed to improve the emotional regulation of children and adolescents by synthesizing data on their efficacy, feasibility, and acceptability in populations without emotional disorders, those at risk of developing them, and those who already have them. The results show that integrating age-appropriate serious games into educational contexts for teaching emotional regulation could improve the mental health and psychological well-being of all students and, consequently, the coexistence between classmates, classroom climate, and teaching and learning processes.

The focus of this study on childhood and adolescence has revealed the potential benefits of serious games in preventing and improving clinical and subclinical emotional symptoms and has provided recommendations for the design and implementation of interventions during this important developmental period. Digital game interventions that incorporated biofeedback provided the strongest evidence of skill transfer. Biofeedback plays a more significant role in the process of identifying and becoming aware of

emotions. Jerčić and Sundstedt [56] conducted a systematic review and found that visual and gameplay biofeedback presentation in serious games increases awareness of emotions and supports emotion-regulation skill in adults. Wang et al. [57] found that, in adults, the combination of biofeedback and game features promotes the use of emotion regulation strategies both during the game and in subsequent tasks, once the biofeedback is removed. The results of this study add to the findings of previous studies by providing evidence of the efficacy, feasibility, and acceptability of serious games in training emotion regulation skills in children and adolescents.

5.2. Practical contributions

It is important to consider the effect on specific emotional regulation strategies based on age. In children, a clearer and more significant effect was observed in strategies related to awareness and regulation of emotional biological signals than in strategies related to cognitive regulation. This effect is understandable, as it reflects the natural acquisition of emotional competencies and their training, which first requires becoming aware of one's own emotions and then developing more complex cognitive skills to regulate them. Developmental differences between children and adolescents imply that younger children may have more difficulty than adolescents in understanding the abstract concepts of cognitive-behavioral therapy due to their stage of cognitive development. For example, the ability to link thoughts, feelings, and behaviors, as well as the ability to recognize one's own thoughts, requires a metacognitive skill that develops later in childhood. This suggests that the real-life relevance of content, rather than fantasy or metaphor, within digital cognitive emotional regulation training may be particularly important for younger children, so the content should clearly relate to the real-life experiences and challenges of the target samples to promote future use of the learned strategies.

Additionally, meta-analytic evidence shows that adaptive emotional control requires the ability to flexibly switch between different emotional control strategies, especially in unknown and rapidly changing situations when the best course of action is uncertain [58]. Thus, the same strategy can be effective, or not, depending on personal and situational demands, such as stimulus intensity and context. For instance, it has been found that the reappraisal strategy, which allows for emotional processing and adaptation, is effective in low emotional intensity situations, while distraction is more effective in high intensity situations, allowing for emotional information to be blocked. Current neurocognitive theories hold that emotion regulation is effective when, in addition to monitoring the effectiveness of the ongoing emotional control strategy, alternative strategies are simultaneously evaluated to allow an individual to decide when to switch to another alternative strategy when necessary [55]. This ability depends on late reappraisal processes, which involve maintaining the emotional control strategy in working memory, monitoring the success of regulation, and monitoring alternative strategies. This process of monitoring alternative strategies has been consistently attributed to the prefrontal cortex, which continues to develop until late childhood and adolescence. Previous research has found that adolescents with poorer emotion regulation outcomes show less maturity and less involvement of the prefrontal cortex, compared to adolescents with better emotion regulation outcomes [58]. The results of this study contribute to this field of research by showing that serious games that dynamically and variably adapt the context and challenges based on age and emotional state, such as SPARX, increase the use of positive coping strategies in adolescents and reduce negative emotional symptoms, such as depression. Furthermore, they support the need to evaluate and train the ability to flexibly switch emotion regulation strategies, and even generate new ones, when the

ongoing strategy does not meet personal or contextual demands. Especially in adolescents, future studies should also examine the impact of gender, baseline scores on outcomes, and success expectations to better understand which students benefit most from the interventions.

5.3. Limitations and future research directions

In both children and adolescents, emotional regulation strategies, such as cognitive reappraisal, may be more linked to future success, rather than immediate success, in reducing negative emotion, i.e., when emotion-inducing stimuli are encountered again at a later date. However, all studies have irregular and limited follow-up time points, so no solid conclusions can be drawn about the long-term sustainability of the intervention effects. Future studies should consider long-term evaluation or follow-up, which would provide the opportunity to study the durability of training effects and allow for analysis of the optimal duration of the intervention that best benefits students.

Another limitation is related to the use of a variety of psychometric scales or clinical assessments without reporting the level of convergence between observer-rated and self-report questionnaires, nor controlling for divergence between them. To advance the field, future studies should consider objectively evaluating improvements in emotional regulation capacity after the intervention and during follow-up. Recent technological advances have made it possible to promote motivation and self-regulation in the learning process of children through novel gamification elements such as Easter eggs [59]. Additionally, these advances have allowed the detection and diagnosis of mental disorders in children through deep learning methods using data obtained from the Bender Gestalt Drawing Test [60]. Interactive technologies such as mobile apps, wearable technologies, tangible objects, and biofeedback and neurofeedback systems allow devices to measure physiological, neurological, and/or behavioral inputs that make invisible mental processes associated with emotion regulation states more visible. A recent review study analyzed a wide range of technology platforms, from laboratory sensors to consumer platforms, aimed at measuring the user's emotional experience through biological data [61]. These measures can act as tracking systems for teachers and researchers to track the emotional regulation skills of each student throughout the learning process. This type of tracking would be especially recommended for students who suffer from, or are at risk of suffering from, emotional or behavioral disorders. The integration of these technologies into serious games would allow detecting, inferring, and representing aspects of the emotional experience through different modalities (i.e., haptic, visual, and auditory), forms (i.e., graphs and numbers, progress in the serious game, movements of tangible objects), and platforms (i.e., mobile devices, wearables, and tangibles). An alternative is the use of digital technology tools through ecological momentary assessment, a methodology that uses mobile devices to collect real-time data on emotional states and emotional regulation processes in people's daily lives [62]. This assessment involves repeated sampling over time of physiological parameters such as electrodermal activity dysregulation and heart rate variability, which are considered indices of emotional regulation capacity, providing intensive longitudinal data. If well designed and validated, these interactive technologies can provide opportunities to learn, practice, evaluate, and accurately track skills associated with emotional regulation both in the classroom and in other contexts of everyday experience.

To optimize acceptability and promote the generalization of learned strategies, it would be advisable to strike a balance between the playful and attractive factors of the game and its real-life relevance. This requires interdisciplinary collaboration at all stages of

conceptualization, specification, and programming and, primarily, taking into account users' opinions. Additionally, to enhance the attractiveness and acceptability of the interventions, it would be interesting to consider the interactive and social component of the games. A recent systematic review on the use of digital technologies in the development of emotional competencies of students with ASD has shown that the practice of emotion regulation skills increases in collaborative virtual learning environments where children and adolescents can communicate with each other through an avatar [63]. In these environments, students interact simultaneously in specific social situations (a recess, a school cafeteria, a birthday party, etc.) where the practice of emotion regulation skills occurs in a naturalistic and ecologically valid way. Hybrid Kinect games have also been shown to promote collaboration and socio-emotional competencies among students with ASD and their neurotypical peers. These games require students to cooperate and interact with each other, not only within the game environment but also in the real world, practicing the skills acquired through symbolic play or sports activities [63]. In this line, recent studies have shown the potential of serious games based on multiplayer Escape Rooms through digital tablets to promote the development of social skills in high-functioning schoolchildren with ASD and facilitate direct communication with their peers through a fun and engaging activity [64]. Future research could consider the design and evaluation of the acceptability of such interventions in neurotypical students. Alternatively, future interventions could include games to be co-played between parents and their children to improve the training of emotional regulation strategies. Past studies [65] have found that digital co-play between parents and children can encourage creative agency, develop self-regulation, and safe, age-appropriate digital technology use, as well as allow children to learn through communicating with parents during gameplay [66]. It would be interesting to find out if digital co-play can enhance the attractiveness and acceptability of the interventions for training emotional regulation strategies in children and adolescents.

Several studies have reported that the effectiveness and adherence to mental health interventions improve with human support. Some participants prefer to have access to a trained supporter in the game, for example, through regular text messages [7, 52]. In this regard, a model for health interventions has been developed, known as "Supportive Accountability", a support process mediated by instant messaging or email, where reciprocity with a coach who is considered trustworthy, benevolent, and experienced increases adherence through accountability [67]. On the other hand, combining elements of virtual and face-to-face therapy could enhance the effectiveness of interventions by providing a comprehensive experience tailored to individual needs. It would be interesting for future research to evaluate whether game interventions should be used in conjunction with or instead of traditional therapies. Would adjunct gaming interventions consolidate the benefits of counselling or traditional cognitive behavioral therapy, for example, or would it render the latter interventions redundant?

Finally, this study shows that serious games may be a promising tool with which educators can integrate the teaching of emotion regulation into existing curricula and daily practices and routines. However, to improve the quality of the program and provide ongoing support to students, future programs should consider training teachers to implement the program in the classroom. Some authors suggest that the teaching of emotional regulation skills begins with supporting educators in developing their own emotional regulation skills, so that children observe and practice these skills at school and at home [55, 68]. Additionally, teachers must understand the social, emotional, and cognitive development of children to ensure that the strategies they teach are age-appropriate. In this regard, it is recommended to improve teacher training offerings by providing broader training

programs that give teachers the opportunity to participate in courses and workshops focused on evidence-based practices such as those used in serious emotional regulation games, for example, some of the techniques of cognitive-behavioral therapy. By learning the basic instructions of these techniques, how and why they work, the teacher will have less difficulty recognizing them in software, will understand how they can support the student's learning process, will be able to implement the interventions with greater fidelity, and will be better equipped to integrate the teaching of emotional regulation into existing curricula and students' daily practices and routines. Along with innovation in teaching processes, it is necessary to introduce technological resources in the classroom. All this leads to teacher training by educational institutions in digital competencies, both in the use of these technologies and in the design of pedagogical models that allow the inclusion of serious games in the curriculum to train emotional regulation skills. Considering that parents are a fundamental element in education, it may be considered important to provide support to families on the benefits and uses of serious games during the learning of emotional regulation strategies. Additionally, it is important that during the design process of these applications, sufficient technical support is provided, such as instruction manuals and tutorial videos, to reduce the possible digital divide. It is also essential that educational institutions have adequate technical staff to provide protection and training services on an ongoing basis, ensuring personal safety and cybersecurity for professionals and students during intervention sessions.

Complete familiarity with all emerging technologies is unlikely, but by understanding the general ways in which some of them can be used, and the basic instructional practices, teachers will be better equipped to benefit from, and benefit students, the most effective technological support tailored to their needs. Additionally, the development of communities of practice or virtual interest groups where experts and teachers meet and exchange ideas in online spaces is presented as an alternative to support the continuous training of teachers. The constant exchange of knowledge and practices that is established in these types of communities or groups makes them a powerful tool for the consolidation of theoretical knowledge, for its application in specific situations, and to promote the necessary reflection that allows improving the level of effectiveness, feasibility, and acceptability of serious games designed to train the emotional regulation skills of children and adolescents in the classroom.

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The review was not registered.

A protocol was not prepared.

Data available on request

Highlights

- Serious games can be useful tools to train emotional regulation.
- Serious play can be effective in preventing and reducing symptoms of depression.
- Serious play can be effective in preventing and reducing symptoms of anxiety.
- For younger children it may be important to include real-life experiences.

Declaration of interests

☒ 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.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: