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Therapeutic Implications of Electronic Gaming for Children with Autism: a Review

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A B S T R A C T

Context: Current evidence regarding electronic gaming for children with autism can be challenging to interpret. This review evaluated the therapeutic implications of electronic gaming for children and adolescents with autism.

Evidence acquisition: CINAHL, PubMed, ProQuest, and Google Scholar databases were utilized to procure articles that were (1) published between the years 2017 and 2022 to encompass contemporary technologies; (2) original studies published in peer-reviewed journals; (3) published in English; (4) level of evidence 2 or higher; (5) subjects included children or young adults aged 0 to 21 years of age with a diagnosis of autism; and (6) the study examined a therapeutic implication of electronic gaming. The two authors independently conducted searches for articles. Article findings were compared against the inclusion/exclusion criteria until a consensus was reached.

Results: Twenty-five articles were included in this review. There was strong evidence supporting the thematic findings of "executive function," and "perceptions and attitudes of caregivers and participants," and moderate evidence for "motor skills," and "social and emotional health."

Conclusions: Electronic gaming was found to be beneficial when addressing executive function, motor skills, and social/emotional health. Caregiver involvement and age-based screen-time guidelines should be promoted to minimize potential harm.

1. Introduction

Autism Spectrum Disorder (ASD) is an increasingly prevalent developmental condition that often causes socialization difficulties, sensory processing challenges, and delays in developmental milestone achievements (Dziuk et al., 2007; Maenner et al., 2021; National Institute of Mental Health, 2022). Autism is represented as a spectrum because there are many different manifestations of the condition. For instance, persons with ASD may struggle to make eye contact during socialization, avoid certain foods or clothing due to textures, or develop school-related skills later than their peers. Although ASD comes with challenges, the condition can also result in unique strengths such as specialty knowledge, attention to detail, and a desire to socialize. Rehabilitation services address symptoms of concern and capitalize on strengths to improve participation and quality of life for children with ASD (Centers for Disease Control and Prevention, 2022).

In recent years, rehabilitation has adapted a top-down, strength-based approach to intervention. In this framework, therapists focus on the holistic client and their strengths to address their concerns (e.g., using a child's love of trains to improve handwriting endurance by writing a story about trains). This contrasts with previous models that focused on deficits (e.g., using endurance theraputty exercises or story writing of non-preferred topics to increase handwriting endurance). Due to this shift in mindset, new therapeutic strategies have been developed. For children with ASD, electronic gaming (EG) has emerged as a potentially innovative therapeutic tool to engage children with ASD in efficacious play-based therapy (Gallo-Lopez & Rubin, 2012; Hillman, 2018).

EG is a constantly evolving umbrella term encompassing all available video gaming and virtual reality (VR) platforms. Common EG implemented in rehabilitation include: the Nintendo Wii, Sony PlayStation, Xbox 360, Microsoft Kinect, and computer-based gaming programs (Aramaki et al., 2019; Cano-Mañas et al., 2020; Ferreira et al., 2020; García-Bravo et al., 2019; Wang et al., 2020). VR and augmented reality (AR) platforms are less common due to novelty and cost, but they have been implemented through research studies (Bowman et al., 2021; Gorman & Gustafsson, 2020; Howard & Davis, 2022; Zhang et al., 2021). Previous literature reviews examined overall therapeutic benefits of EG (Granic et al., 2014; Horne-Moyer et al., 2014). Previous systematic reviews investigated specific types of video games (i.e., serious games, exergames, computer-based games) or specific therapeutic goals for children with ASD (Fang et al., 2019; Grossard et al., 2017; Jiménez-Muñoz et al., 2022; Wass & Porayska-Pomsta, 2014).

Since the integration of EG into healthcare, researchers have invested resources and efforts in investigating the potential advantages and disadvantages of its use. EG has been found to be

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highly motivating and therapeutically beneficial for common pediatric conditions such as cerebral palsy (CP), Erb's palsy, attention deficit hyperactivity disorder (ADHD), acquired brain injuries (ABI), and cancer (Goyal et al., 2022; Griffiths, 2003; Kato et al., 2008; Levac et al., 2012; Lohse et al., 2013; Metin Ökmen et al., 2019; Peñuelas-Calvo et al., 2022). Specifically, VR increased motor function while computer-based games improved cognition, self-efficacy, and knowledge (Goyal et al., 2022; Kato et al., 2008; Metin Ökmen et al., 2019; Peñuelas-Calvo et al., 2022). Regarding ASD, caregivers and persons with ASD have historically been supportive of EG use, stating that they believe it to be beneficial to development and well-being (Finke et al., 2015; Laurie et al., 2018; Mazurek et al., 2015).

While there are many benefits to implementing EG for pediatric rehabilitation, several drawbacks have been identified. It is well known that EG requires an investment of clinic resources (e.g., monetary for purchase and maintenance, space for storage and use, and time for therapist training). Additionally, potential harm to the client through problematic video game (PVG) use and gaming disorder (GD) has been described (Craig et al., 2021; Levac et al., 2012; Murray et al., 2022).

GD has been recognized by the International Classification of Diseases (ICD-11) and describes impaired control over video game usage while PVG use is associated with addictive behaviors (Craig et al., 2021; World Health Organization, 2022). Children with ASD may be at a greater risk for GD and PVG use than their peers who are typically developing because children with ASD use EG with greater frequency and duration (Engelhardt et al., 2017; Mazurek & Engelhardt, 2013; Mazurek et al., 2012). Most research suggests that the likelihood of a child with ASD developing PVG use is dependent upon individual factors, such as a lack of parental guidance, attention problems, or oppositional behavior (Craig et al., 2021; Saunders et al., 2017).

The debate surrounding the use of EG for children with ASD is further complicated by the opinions of parents and persons with ASD. Parents of children with ASD generally supported the use of EG and viewed video game play positively (Finke et al., 2015; Laurie et al., 2018). Similarly, children with ASD who utilize EG reported that they believed gaming benefitted them emotionally and developmentally (Finke et al., 2018). Furthermore, adults with ASD perceived that EG enhanced their social connectedness and relieved stress, outweighing concerns such as time use and addiction (Mazurek et al., 2015).

Current evidence regarding EG for children with ASD can be challenging for therapists and caregivers to interpret into implementable guidelines. Existing comprehensive reviews examined the overall therapeutic benefits of EG (Granic et al., 2014; Horne-Moyer et al., 2014). Reviews focused on children with ASD were limited to specific types of games (e.g., serious games, exergames, computer-based training) or specific therapeutic goals (Fang et al., 2019; Grossard et al., 2017; Jiménez-Muñoz et al., 2022; Wass & Porayska-Pomsta, 2014). Although these reviews were valuable and timely, up-to-date practical recommendations for clinicians and caregivers were not provided. The review answered the question, "Can EG be used therapeutically with pediatrics with ASD?" The findings of this review will provide up-to-date practical recommendations for both therapists and caregivers, ultimately benefiting children with ASD.

2. Methods

This review utilized previously published articles and, as such, did not employ human subjects. The studies referenced by this review followed the ethical standards and received the confirmation of the responsible committee for human or animal investigation as well as to the Declaration of Helsinki of 1975, revised in 2008.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were adhered to for this review (Moher et al., 2015). Four databases were utilized to conduct a comprehensive search of the literature: CINAHL, PubMed, ProQuest, and GoogleScholar. Search terms included combinations of the following: autism, autism spectrum disorder, autistic, ASD, video gaming, video games, online gaming, virtual reality, children, adolescents, youth, child, teenager, pediatric, kids, therapy, rehabilitation, and interventions.

The following inclusion criteria were utilized to select articles: (1) published between the years 2017 and 2022 to encompass a contemporary 5-year span; (2) original studies published in peer-reviewed journals; (3) published in English; (4) level of evidence 2 or higher based on the John Hopkins nursing hierarchy (Dearholt & Dang, 2018); (5) subjects included children aged 0 to 21 years of age with a diagnosis of ASD; and (6) the study examined a therapeutic implication of a video game or virtual reality platform. Searches were limited to full text and scholarly, peer-reviewed journals. A manual search was conducted to identify additional studies through references embedded within articles.

Studies were excluded based on the following criteria: (1) feasibility studies; (2) published before the year 2017 to encompass contemporary technologies; (3) abstracts as these studies are difficult to replicate due to the brevity of the report or dissertations that did not undergo a blind peer-review process; (4) ongoing clinical trials; (5) level of evidence 3 or below; (6) subjects with diagnoses other than ASD; (7) interventions that included robot-based technology; and (8) studies using electronic gaming aimed towards diagnosing or assessing ASD.

The two authors independently conducted searches for articles. Studies were selected by comparing titles, abstracts, and then full text against the inclusion/exclusion criteria. Article selections were then compared amongst the authors. All articles included in this review were deemed appropriate by both authors.

3. Results

Figure 1 illustrates the search strategy and study selection process. Ultimately, 25 articles met the inclusion criteria for this review. **Table 1** consists of the respective methodology, level of evidence, and results of each study included in the review. A total of 12 studies were level 1 randomized clinical trials, while the remaining 13 studies were level 2 quasi-experimental studies. During in-depth analysis of the included articles, four themes emerged: executive function; motor skills; social and emotional health; and perceptions and attitudes of caregivers and participants. Strength of evidence for each theme and findings throughout were determined utilizing the American Occupational Therapy Association (AOTA; 2020) criteria. Overall, there was strong evidence supporting the use of EG for executive function and perceptions and attitudes of caregivers and participants, and moderate evidence for motor skills and social and emotional health (AOTA, 2020).

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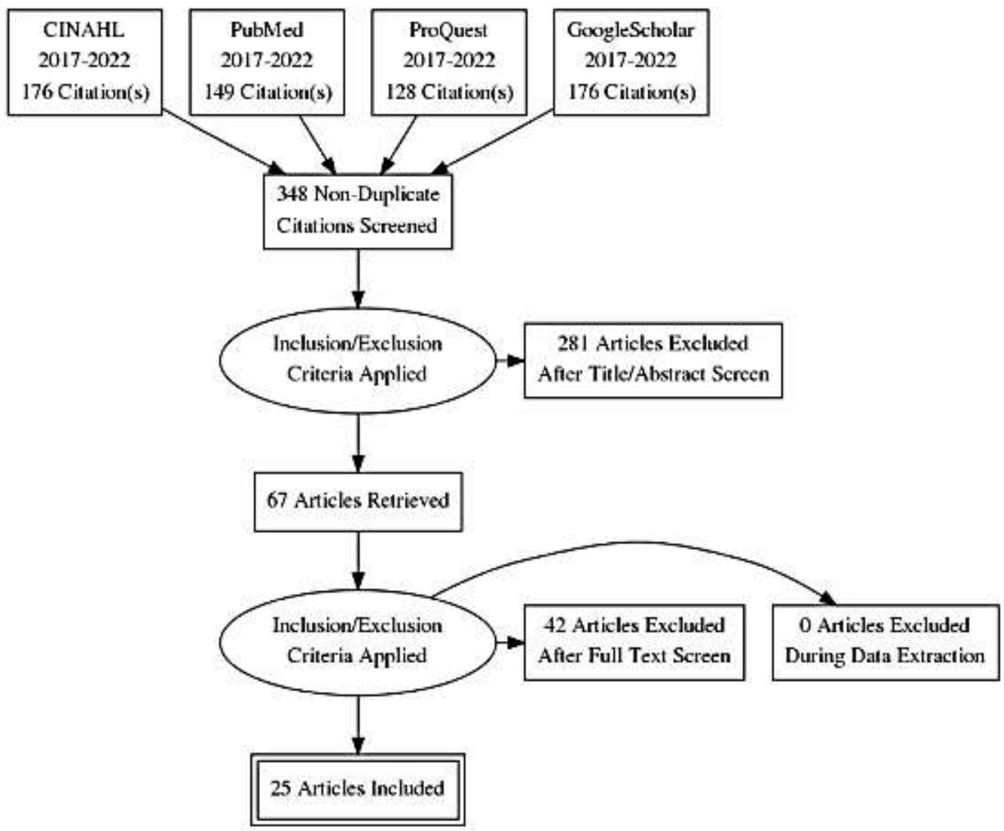

Figure 1. *Study selection and search strategy.*

Table 1.
Article Assessment Table

Authors	Aim	Subjects	Methodology	Level	Results
Antao et al., 2020	Investigating an augmented reality (AR) personal computer (PC) game (MoviLetrando) with letters and numbers to improve performance & reaction time skills	96 participants divided into two groups: 48 children with ASD aged 7-28 years (experimental) and 48 children who were typically developing (TD) aged 7-27 years (control)	Quasi-experimental	2	Only the ASD group showed an improvement in reaction times after playing the AR PC game. Reaction time was associated with cognition & motor performance.
Beaumont et al., 2021	Evaluating a video game-based social skills program (Secret Agent Society – SAS) by using parent/teacher reported social skills, when compared to compared to Central Intelligence Agency (CIA) game	70 children with ASD aged 7-12 years (35 SAS intervention, 35 CIA control)	Randomized controlled trial (RCT)	1	SAS participants significantly improved social-emotional functioning on parent-report measures compared to the control group.
Chukoskie et al., 2018	Utilizing Mole Whack, Space Race, & Shroom Digger (PC & eye tracker) to	8 children with ASD (mean age = 13.9 years)	Quasi-experimental	2	4 out of 6 participants showed significant improvement in duration

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	improve visuo-spatial attention & eye movement control				of gaze fixation. 5 out of 6 participants significantly improved attention performance. 4 out of 6 participants significantly reduced time to disengage attention, and after 8 weeks, 1 continued to improve while the others sustained improvement.
Corbett et al., 2018	Examining cortisol production to measure stress response to peer interaction with Wii Sports Bowling	12 children with ASD and 12 age-matched adolescents who were typically developing (TD) aged 13-17 years old	Quasi-experimental	2	No significant differences were found between the children in the ASD and TD groups' cortisol production after playing Wii Sports Bowling. A stress response was not elicited adolescents in the ASD group.
Edwards et al., 2017	Investigating Xbox Kinect Sports Seasons 1 and 2, Sports Rivals, and Kinect Adventures to improve object control skills	11 children with ASD (intervention) and 19 children who were TD (control) aged 6-10 years	RCT	1	No significant increase in object control skills after playing Kinect Sports was found. The children with ASD's perceptions of their motor skills improved, and parents reported multiple positive benefits as a result of playing the games.
Finke et al., 2017	Assessing eye tracking and attention during Xbox One videogame play (LEGO Marvel Superheroes)	11 children with ASD aged 8-17 years and 8 children who were TD aged 11-20 years	Quasi-experimental	2	No significant difference was found between the children in the ASD and TD groups. Each group referenced the videogame player equally and visually attended to videogame stimuli for similar durations.
Fridenson-Hayo et al., 2017	Cross-culturally examining the Emotiplay (PC) serious game to improve emotion recognition in the United Kingdom (UK), Israel, and Sweden.	89 children with ASD aged 6-9 years divided into five groups: 15 intervention in UK, 18 intervention in Israel, 20 controls in Israel, 16 intervention in Sweden, 20 controls in Sweden	RCT	1	For the UK Phase 1 trial, participants significantly improved emotion regulation, body language, and integrative task performance. Parents rated children significantly higher on the socialization scale of the Vineland Adaptive Behavior Scales (VABS-II), while ratings on the Social Responsiveness Scale (SRS-2) did not change. In the Israel and Sweden trials, participants in the intervention groups showed significant improvements in all emotional recognition tasks compared to the

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					control groups. Israeli parents also rated autistic symptoms of their children significantly lower on the SRS-2.
Frolli et al., 2022	Evaluating a virtual reality (VR) emotional literacy program through recorded scenes	60 children with ASD aged 9-10 years	Quasi-experimental	2	There were significant differences in the acquisition times for recognition of primary emotions for both interventions, however, acquisition times were shorter with the use of VR.
Ji et al., 2022	Comparing effects of virtual training (Xbox 360) versus physical exercise on executive function	100 children with ASD were assigned to three groups: virtual training (34 with mean age = 12.5 years), physical exercise (33 with mean age = 13.1 years), and control (33 with mean age = 12.8 years).	RCT	1	Both virtual training and physical exercise effectively improved children's executive function after six weeks of intervention. After stopping training for three weeks, it was found that executive function began to decline.
Johnston et al., 2020	Investigating a VR game (SoundFields) to decrease auditory hypersensitivity	6 adolescents with ASD aged 16-19 years	Quasi-experimental	2	A significant decrease in self-reported anxiety following the use of the VR game was found. There was also a significant increase in tracked interaction time between sessions 1 and 4, which is evidence of increased tolerance to auditory stimuli.
Jouen et al., 2017	Utilizing Gaming Open Library for Intervention in Autism at Home (GOLIAH) serious games to explore imitation and joint attention	14 children with ASD exposed to GOLIAH and 10 ASD children treated as usual aged 5-8 years	Quasi-experimental	2	A significant improvement in Parenting Stress Index (PSI) scores was noted for both groups. A significant improvement was found among 4 of 6 imitation games and an improvement in time to complete tasks among 3 of 4 joint attention games. Overall, there was no significant change for time and group interaction, as both gaming and non-gaming groups improved Autism Diagnostic Observation Schedule (ADOS), Vineland, Child Behavior Checklist (CBCL), and PSI scores.
Kalantarian et al., 2019	Evaluating "Guess What?" mobile game in identifying facial emotions	8 children with ASD (mean age = 8.5 years)	Quasi-experimental	2	A high percentage of frames were labeled correctly for disgust, scared, neutral, and surprised emotions, but

					not for happy or angry emotions.
Kouhbanani et al., 2021	Assessing VR-based Treatment and Education of Autistic and Communication Handicapped Children (TEACCH) method in combination with risperidone to improve behavioral and social skills	43 children with ASD aged 6-12 years divided into three groups (15 risperidone, 15 risperidone & VR, 13 control)	RCT	1	Risperidone and VR group had significant differences in social skills and behavioral symptoms compared to the control group. Risperidone group showed significant differences in social skills and behavioral symptoms only in post-test, intervention groups did not have any significant difference post-test.
Lamash et al., 2017	Utilizing a virtual reality supermarket as a meta-cognitive intervention to improve independent functioning	56 adolescents with ASD aged 11-19 divided into two groups (37 intervention, 25 control)	Quasi-experimental	2	Participants in the intervention group significantly improved scores in all four indices: accuracy, time, redundancy, and strategies used, while the control group showed significant improvement in time, redundancy, and strategies used. The intervention group also showed significant improvements in the attention and executive functions as compared to the control group. A significant decrease in verbal component was found for both groups.
Macoun et al., 2021	Using a game-based cognitive training program, Caribbean Quest (PC), to improve executive function and attention	20 children with ASD aged 6-12 years divided into two groups (11 intervention, 9 control)	RCT	1	Statistically significant differences were found between the intervention and control group for selective attention, visual-spatial working memory, and academic fluency. Post-test errors were significantly lower in the intervention group than the control group for each task. No significant difference was found on measures of verbal working memory, sustained attention, or divided attention/cognitive flexibility.

Malihi et al., 2020	Evaluating safety and usability of VR (Oculus Rift) use compared to monitor displayed video	35 children with ASD aged 8-18 years (mean age = 13)	Quasi-experimental	2	A significant increase in self-reported anxiety was found after the VR task. The VR and control group did not significantly differ on reporting negative effects, with none reporting nausea. The most common negative effects reported were tiredness, eye strain, and headache. Participants reported significantly enhanced spatial presence and naturalness in the VR group, with 74% preferring VR over monitor displayed video. Greater scores were not found for engagement. Three parents reported that the experience positively impacted their child's feeling about riding a school bus.
Mercado et al., 2021	Utilizing a brain-computer interface (BCI) game, FarmKeeper (PC), to support neurofeedback training	26 children with ASD aged 4-13 years divided into two groups (13 intervention, 13 control)	RCT	1	Participants in the intervention group showed slightly greater improvement in sustained attention compared to the control group. 10 out of 12 intervention participants made fewer changes between being distracted and focused, while the control group made more changes than the average number of changes in the intervention group. 10 out of 10 teachers agreed that the FarmKeeper game can improve participants' attention better than the Cartoons in the control group.
Milajerdi et al., 2021	Examining Sports, Play and Active Recreation for Kids (SPARK) and exergaming (Kinect) on motor skills and executive functions	60 children with ASD aged 6-10 years divided into three groups (20 SPARK intervention, 20 Kinect intervention, 20 control)	RCT	1	A significant improvement was found in aiming and catching skills as well as in correct responses. Children in all 3 groups showed improvement in executive functioning. The SPARK group improved significantly from pre to post-test and the Kinect group had more correct responses than the SPARK group. No significant

					improvements were found in manual dexterity, balance, or motor skills.
Serret et al., 2017	Investigating SEMA-TIC (PC), a puzzle game, to improve literacy skills and reading comprehension	25 children with ASD divided into two groups (12 intervention with mean age = 8.7 years, 13 control with mean age = 8.5 years)	Quasi-experimental	2	Strong motivation to play was found in 75% of participants. Significant improvements in literacy skill performance and the segmentation task were found in the intervention group compared to the control group.
Sosnowski et al., 2022	Exploring the feasibility, acceptability, and efficacy of Lookware (PC) video game combining applied behavior analysis and gaze-contingent eye tracking techniques for emotion recognition	54 children with ASD aged 4-14 years divided into two groups (25 intervention, 29 control)	RCT	1	Significant improvements in emotion recognition from pre to post-test were found in the intervention group as compared to the control group.
Spaniol et al., 2018	Utilizing a Computerized Progressive Attentional Training (CPAT) at-school attentional (PC) game in the UK to improve academic performance & behavior	15 children with ASD aged 6-10 years divided into two groups (8 intervention, 7 active control)	RCT	1	The intervention group showed improvements in several academic tests including maths, reading comprehension, and copying speed. No evidence of change in autistic symptoms were found. No significant difference was found in behavior between the two groups.
Travers et al., 2018	Assessing Ninja training game (Kinect and Nintendo Wii) exergame to improve body balance through biofeedback	29 children with ASD aged 7-17 years	Quasi-experimental	2	Significant improvements in balance times using the novel in-lab video game were found. Performance improvements were also noted using the Nintendo Wii Fit game. Participants and family members reported enjoying the interventions and finding them beneficial.
Vukicevic et al., 2019	Utilizing Fruits and Rackets Games (VR and AR Kinect-based) to improve motor skills	10 children with ASD aged 9-13 years divided into two groups (5 intervention, 5 control)	RCT	1	The intervention group improved in average Racket game score, which is associated with improved motor skills. The motor skills gained in the Fruits game were found to be transitive to the Rackets game. Participants also completed the games in shorter durations as sessions progressed, indicating an increase in skill. No improvements

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					in scores were observed in the control group.
Wagle et al., 2021	Using tablet/smartphone games (Basket, Train, Piano, Face, & Shape game) to improve working memory and examine collateral gains	13 children with ASD and 1 child with Down's Syndrome aged 6-13 years	Quasi-experimental	2	No significant differences were noted between working memory or autistic symptoms after short-term training. Children who performed better on games were more likely to show improvements in working memory.
Wijnhoven et al., 2020	Investigating Mindlight (PC) to reduce anxiety symptoms	109 children with ASD aged 8-16 years divided into two groups (53 intervention, 56 control)	RCT	1	A significantly greater decrease in parent-rated anxiety in the intervention group was found as compared to the control group.

3.1. Executive Function

Twelve studies investigated executive function (e.g., attention, academic performance, working memory, and meta-cognition; Antão et al., 2020; Chukoskie et al., 2018; Finke et al., 2017; Ji et al., 2022; Jouen et al., 2017; Lamash et al., 2017; Macoun et al., 2021; Mercado et al., 2021; Milajerdi et al., 2021; Serret et al., 2017; Spaniol et al., 2018; Wagle et al., 2021). For instance, significant improvements in attention were found in five studies (Chukoskie et al., 2018; Jouen et al., 2017; Lamash et al., 2017; Macoun et al., 2021; Mercado et al., 2021). Specifically, one article noted significant improvements in executive function and attention following a meta-cognitive virtual SuperMarket intervention, promoting independent functioning (Lamash et al., 2017). Only one study failed to find significant results (Finke et al., 2017). Overall, since two level 1 studies found significance, there was strong evidence supporting the use of EG for attention (AOTA, 2020; Macoun et al., 2021; Mercado et al., 2021).

Significant improvements in academic performance (e.g., literacy skills, academic fluency, test scores) and cognitive performance were found in four studies (Antão et al., 2020; Macoun et al., 2021; Serret et al., 2017; Spaniol et al., 2018). Additionally, two studies noted significant improvements in working memory, which is necessary for learning (Macoun et al., 2021; Wagle et al., 2021). Only one article reported insignificant improvements in working memory (Ji et al., 2022). Overall, there was strong evidence (i.e., two level 1 studies) supporting the use of EG for academic performance and moderate evidence (i.e., one level 1 and one level 2 study) for working memory (AOTA, 2020; Macoun et al., 2021; Spaniol et al., 2018; Wagle et al., 2021).

Eight studies utilized PC games as interventions (Antão et al., 2020; Chukoskie et al., 2018; Jouen et al., 2017; Lamash et al., 2017; Macoun et al., 2021; Mercado et al., 2021; Serret et al., 2017; Spaniol et al., 2018). Two studies utilized Xbox consoles (i.e., Xbox One, Xbox 360; Finke et al., 2017; Ji et al., 2022). One study utilized Microsoft Kinect (Milajerdi et al., 2021). Another study utilized smartphone-based games (Wagle et al., 2021). One study utilized an AR PC game (Antão et al., 2020). Another study employed an eye tracking device (Chukoskie et al., 2018).

Overall, while ten studies total found improvements in executive function, the two studies that failed to find significant results utilized EG platforms that differed from the other studies (e.g., Xbox One, smartphone-based; Finke et al., 2017; Wagle et al., 2021). Most studies that identified significant findings utilized motivational factors as forms of positive reinforcement within their interventions (Jouen et al., 2017; Macoun et al., 2021; Serret et al., 2017). Although there was variability in the EG platforms utilized, five significant studies utilized PC games specifically developed for children or adolescents with ASD or other medical diagnoses (Chukoskie et al., 2018; Jouen et al., 2017; Lamash et al., 2017; Macoun et al., 2021; Serret et al., 2017). In conclusion, there was strong evidence supporting the use of EG for executive function.

3.2. Motor Skills

Six studies examined motor skills in children with ASD (Antão et al., 2020; Chukoskie et al., 2018; Edwards et al., 2017; Milajerdi et al., 2021; Travers et al., 2018; Vukićević et al., 2019). Improvements in motor skills (e.g., eye-movement control, reaction time, balance) were described in three articles (Antão et al., 2020; Chukoskie et al., 2018; Travers et al., 2018). Three additional studies demonstrated significant improvement in gross motor skills (i.e., balance, aiming and catching skills), which equated to moderate strength evidence (Milajerdi et al., 2021; Travers et al., 2018; Vukićević et al., 2019). One study found that participants' perceptions of motor skills improved, however, the difference between pre and post scores were not significantly different (Edwards et al., 2017).

Most studies utilized the Microsoft Kinect sensor to deliver motor skill interventions (Edwards et al., 2017; Milajerdi et al., 2021; Travers et al., 2018; Vukićević et al., 2019). One study utilized the Nintendo Wii Fit (Travers et al., 2018). One study employed an AR PC game (Antão et al., 2020). Another study utilized both PC and eye tracking devices (Chukoskie et al., 2018). Three of the studies that found significant results utilized games specifically designed for children with ASD and the Microsoft Kinect sensor, along with incorporating motivational elements by offering in-game rewards as positive reinforcement (Milajerdi et al., 2021; Travers et al., 2018; Vukićević et al., 2019). Overall, there was moderate evidence (i.e., one level 1 study and five level 2 studies) supporting the use of EG for motor skills (AOTA, 2020; Milajerdi et al., 2021).

3.3. Social and Emotional Health

Four studies investigated emotion recognition skills in children with ASD (Fridenson-Hayo et al., 2017; Frolli et al., 2022; Kalantarian et al., 2019; Sosnowski et al., 2022). Improvements in identification of facial emotions were found in one study (Kalantarian et al., 2019). Significant improvements in emotion recognition were described in three studies (Fridenson-Hayo et al., 2017; Frolli et al., 2022; Sosnowski et al., 2022). Overall, there was strong evidence (i.e., two level 1 studies) supporting the use of EG for emotion recognition skills (AOTA, 2020; Fridenson-Hayo et al., 2017; Sosnowski et al., 2022).

Three studies investigated social, emotional, and behavioral implications of EG (Beaumont et al., 2021; Corbett et al., 2018; Kouhbanani et al., 2021). Beaumont et al. (2021) found a significant improvement in social-emotional functioning per parent reports. Kouhbanani et al., (2021) described significant improvement in social and behavioral problems in both intervention groups. Similarly, one study investigated children with ASD who also had auditory hypersensitivity and found a significant decrease in self-reported anxiety (Johnston et al., 2020). Additionally, Corbett et al. (2018) identified a lack of a stress response in children with ASD during peer interaction, supporting the use of EG to develop social skills. Overall, there was moderate evidence supporting EG for social-emotional functioning.

Three studies utilized PC games, which all identified significant improvements in emotion recognition or social-emotional functioning (Beaumont et al., 2021; Fridenson-Hayo et al., 2017; Sosnowski et al., 2022). Three studies utilized a VR device (e.g., Oculus Rift, VR glasses), all of which found significant results (Frolli et al., 2022; Johnston et al., 2020; Kouhbanani et al., 2021). Corbett et al., (2018) utilized the Nintendo Wii console, which did not identify significant differences in stress response between the intervention and control groups. Additionally, Kouhbanani et al. (2021) utilized a mobile-based application via Bluetooth along with VR glasses to deliver the intervention. Kalantarian et al. (2019) utilized a mobile-based game, which failed to find significant results.

Three studies incorporated motivational elements into the game's design, allowing opportunities to receive rewards as a form of positive reinforcement, for which all found significant results (Fridenson-Hayo et al., 2017; Johnston et al., 2020; Sosnowski et al., 2022). Four studies did not report motivational components or rewards in their interventions (Corbett et al., 2018; Frolli et al., 2022; Kalantarian et al., 2019; Kouhbanani et al., 2021). One did not find significant results, ultimately supporting the use of EG (Corbett et al., 2018). Another failed to find significant results, which did not support the use of EG (Kalantarian et al., 2019). Overall, there was moderate evidence (i.e., one level 1 study) supporting the use of EG for social, emotional, and behavioral functioning (AOTA, 2020; Kouhbanani et al., 2021).

3.4. Perceptions and Attitudes of Caregivers and Participants

Twelve studies reported the perceptions and attitudes of caregivers or participants toward the intervention (Beaumont et al., 2021; Edwards et al., 2017; Fridenson-Hayo et al., 2017; Jouen et al., 2017; Macoun et al. 2021; Malihi et al., 2020; Mercado et al., 2021; Serret et al., 2017; Sosnowski et al., 2022; Travers et al., 2018, Vukićević et al., 2019; Wijnhoven et al., 2020). For instance, teachers reported positive feedback in two studies (Macoun et al., 2021; Mercado et al., 2021). Similarly, staff reported positive feedback in one study (Sosnowski et al., 2022). Therefore, there was strong evidence for the opinions of teachers and staff (AOTA, 2020).

Positive feedback was reported from caregivers (i.e., parents, family members) in nine studies (Beaumont et al., 2021; Edwards et al., 2017; Fridenson-Hayo et al., 2017; Jouen et al., 2017; Macoun et al. 2021; Malihi et al., 2020; Serret et al., 2017; Travers et al., 2018, Wijnhoven et al., 2020). In two studies, parents rated higher socialization skills with a decrease in ASD symptoms and a significant increase in social-emotional scores for their children post-intervention (Beaumont et al., 2021; Fridenson-Hayo et al., 2017). Two studies identified parental benefits, such as a significant decrease in parent-rated anxiety and lack of an increase in parental stress following participation in the EG intervention with their children (Jouen et al., 2017; Wijnhoven et al., 2020). Additionally, five studies found positive reports (i.e., strong motivation to play, increase in positive emotions, enjoyable) from participants in the intervention group (Malihi et al., 2020; Serret et al., 2017; Sosnowski et al., 2022; Travers et al., 2018; Vukićević et al., 2019). Overall, there was strong evidence (i.e., six level 1 studies) supporting the use of EG for perceptions and attitudes of caregivers and participants (AOTA, 2020; Beaumont et al., 2021; Fridenson-Hayo et al., 2017; Macoun et al. 2021; Mercado et al., 2021; Sosnowski et al., 2022; Wijnhoven et al., 2020).

Eight studies utilized PC games to deliver interventions (Beaumont et al., 2021; Fridenson-Hayo et al., 2017; Jouen et al., 2017; Macoun et al., 2021; Mercado et al., 2021; Serret et al., 2017; Sosnowski et al., 2022; Wijnhoven et al., 2020). Three studies utilized the Microsoft Kinect sensor (Edwards et al., 2017; Travers et al., 2018; Vukićević et al., 2019). One study utilized a VR device (Malihi et al., 2020) one study utilized an eye-tracking device (Sosnowski et al., 2022) and one study utilized the Nintendo Wii console (Travers et al., 2018).

Three of the studies also examined attention (Jouen et al., 2017; Macoun et al., 2021; Mercado et al., 2021). Three studies also investigated motor skills (Edwards et al., 2017; Travers et al., 2018; Vukićević et al., 2019). Two of the studies also examined emotion recognition (Fridenson-Hayo et al., 2017; Sosnowski et al., 2022). One study also assessed academic performance (Serret et al., 2017). Seven studies incorporated motivational components by offering in-game rewards as positive reinforcement (Fridenson-Hayo et al., 2017; Jouen et al., 2017; Macoun et al., 2021; Serret et al., 2017; Sosnowski et al., 2022; Travers et al., 2018, Vukićević et al., 2019). In general, all studies that explored caregiver and participant perceptions had positive findings with strong supporting evidence.

3.5. Subjects

Most of the studies included in this review spanned multi-age groups. The youngest subjects were 4 years of age (Mercado et al., 2021; Sosnowski et al., 2022). Only three studies included preschool aged (3-5-year-old) children (Jouen et al., 2017; Mercado et al., 2021; Sosnowski et al., 2022). Most studies, 20 out of 25, included middle childhood (6-11-year-old) children (Antão et al., 2020; Beaumont et al., 2021; Edwards et al., 2017; Finke et al., 2017; Fridenson-Hayo et al., 2017; Frolli et al., 2022; Jouen et al., 2017; Kalantarian et al., 2019; Kouhbanani et al., 2021; Macoun et al., 2021; Malihi et al., 2020; Mercado et al., 2021; Milajerdi et al., 2021; Serret et al., 2017; Sosnowski et al., 2022; Spaniol et al., 2018; Travers et al., 2018; Vukićević et al., 2019; Wagle et al., 2021; Wijnhoven et al., 2020). A large portion of the studies, 17 out of 25, also included pre-teen to young adult (12-21-year-old) subjects (Antão et al., 2020; Beaumont et al., 2021; Chukoskie et al., 2018; Corbett et al., 2018; Finke et al., 2017; Ji et al., 2022; Johnston et al., 2020; Kouhbanani et al., 2021; Lamash et al., 2017; Macoun et al., 2021; Malihi et al., 2020; Mercado et al., 2021; Sosnowski et al., 2022; Travers et al., 2018, Vukićević et al., 2019; Wagle et al., 2021; Wijnhoven et al., 2020). Overall, the findings of this review are most applicable to middle childhood to young adult (6-21-year-old) persons with ASD.

3.6. Platforms

Overall, there was strong evidence supporting the use of EG for executive function (specifically attention, academic performance, and moderately for working memory), with most studies implementing PC games (Jouen et al., 2017; Macoun et al., 2021; Mercado et al., 2021; Serret et al., 2017; Spaniol et al., 2018; Wagle et al., 2021). There was moderate evidence for gross motor skills, for which most utilized the Microsoft Kinect sensor (Milajerdi et al., 2021; Travers et al., 2018, Vukićević et al., 2019). There was moderate evidence supporting the use of EG for social and emotional health (specifically social, emotional, and behavioral functioning and strongly for emotion recognition), with most studies implementing PC and VR games (Beaumont et al., 2021; Fridenson-Hayo et al., 2017; Frolli et al., 2022; Kouhbanani et al., 2021; Sosnowski et al., 2022). Furthermore, there was strong evidence supporting the use of EG for perceptions and attitudes of caregivers (including teachers, staff, and parents) and participants, for which most utilized PC games (Beaumont et al., 2021; Fridenson-Hayo et al., 2017; Jouen et al., 2017; Macoun et al., 2021; Mercado et al., 2021; Sosnowski et al., 2022; Spaniol et al., 2018; Vukićević et al., 2019; Wijnhoven et al., 2020). The games utilized in significant studies were most often designed specifically for children with medical diagnoses and/or had a built-in motivational component (Beaumont et al., 2021; Vukićević et al., 2019; Wagle et al., 2021). **Table 2** summarizes the findings from the systematic review analysis.

Five studies specifically utilized serious games, which are games designed to target specific skills and challenge the player (Fridenson-Hayo et al., 2017; Johnston et al., 2020; Jouen et al., 2017; Macoun et al., 2021; Serret et al., 2017; Whyte et al., 2015). Serious games are intended to develop learning that is generalizable to real-life settings by utilizing evidence-based educational theories (Whyte et al., 2015). A key principle of serious games is the inclusion of intrinsic motivational in-game rewards and the use of immersive storylines to encourage emotional learning (Whyte et al., 2015).

Of the reviewed articles, five out of the 25 studies failed to find significant results (Corbett et al., 2018; Edwards et al., 2017; Finke et al., 2017; Kalantarian et al., 2019; Wagle et al., 2021). Of these studies, none incorporated motivational elements or offered in-game rewards. Although Corbett et al. (2018) did not identify a significant difference in stress response, these results ultimately support the use of EG for social and emotional health.

Table 2.
Summary Findings

Theme Strength	Subtheme(s) Strength	Common Platform	Game Description
Executive Function (Strong)	Attention (Strong), Academic Performance (Strong), and Working Memory (Moderate)	PC	Developed specifically for medical diagnoses with motivational component
Motor Skills (Moderate)	Gross Motor (Moderate)	Microsoft Kinect	Developed specifically for medical diagnoses with motivational component
Social and Emotional Health (Strong)	Emotion Recognition (Strong) and Social, Emotional, and Behavioral Functioning (Strong)	PC and VR	Motivational component with in-game rewards
Perceptions and Attitudes of Caregivers and Participants (Strong)	Teachers/Staff (Strong), Parents (Strong), and Participants (Strong)	PC	Developed specifically for medical diagnoses with motivational component

4. Discussion and conclusion

Overall, a total of 25 studies that examined the therapeutic implications of utilizing EG for children and adolescents with ASD were included in this systematic review. Fourteen studies utilized small sample sizes of less than 30 total participants (Chukoskie et al., 2018; Corbett et al., 2018; Edwards et al., 2017; Finke et al., 2017; Johnston et al., 2020; Jouen et al., 2017; Kalantarian et al., 2019; Macoun et al., 2021; Mercado et al., 2021; Serret et al., 2017; Spaniol et al., 2018; Travers et al., 2018; Vukićević et al., 2019; Wagle et al., 2021). Although the small sample sizes of some studies were a limitation for the generalizability of the results, many of the articles were of higher quality and strengthened the overall evidence of the thematic findings.

Findings from this review are consistent with those found in previous reviews, such as describing significant improvements in executive function, academic performance, participant perceptions, motor skills, socialization, emotion recognition, and social-emotional functioning (Fang et al., 2019; Granic et al., 2014; Horne-Moyer et al., 2014; Jiménez-Muñoz et al., 2022; Wass & Porayska-Pomsta, 2014). However, this review also found evidence that EG supports improvement of attention, working memory, and perceptions and attitudes of caregivers and participants, which was not discussed in previous reviews. Furthermore, this review discovered that specific types of EG, such as PC, Microsoft Kinect, and VR platforms are effective mediums for delivering therapeutic interventions in children and adolescents with ASD.

Based on the positive findings from this review, EG is recommended for therapeutic use when adhering to the age-based recommendations for screen time (American Academy of Child & Adolescent Psychiatry [AACAP], 2020; American Psychological Association [APA], 2020). For children aged 2 to 5 years old, it is recommended to limit screen time to one hour during weekdays and three hours during weekend days (AACAP, 2020). For children over the age of 6, it is recommended to utilize age-appropriate content, limit the amount of screen time, and encourage healthy online habits (AACAP, 2020). Exceeding age-appropriate screen recommendations through use in the clinic and/or at home may have consequences that outweigh the benefits (Craig et al., 2021; Murray et al., 2022; Must et al., 2014). For example, one study found that children engaging specifically in competitive gaming for more than 8 hours per week may cause a decrease in prosocial behavior (Lobel et al., 2017). Therapists must collaborate with caregivers to mitigate this risk and maximize the benefits that gaming can offer.

Given the high percentage of positive attitudes and perceptions of caregivers and participants discovered in the studies reviewed, EG could be implemented into rehabilitation to promote adherence to treatment and carryover at home. EG evidence supports the translation of video gaming in the home, specifically alongside family and friends, as it can promote social skill development (Corbett et al., 2018; Kouhbanani et al., 2021). As always, the age and maturity of the child should be considered when suggesting such games. Caregiver involvement is highly preferred to monitor, model, and guide during social engagements.

When utilizing EG for children with ASD, concerns include the development of PVG use, GD, and an increase in sedentary behaviors (Craig et al., 2021; Murray et al., 2022; Must et al., 2014). Adhering to screen time recommendations helps to mitigate these risks (AACAP, 2020; APA, 2020). Therapists must also be aware that some games contain explicit or inappropriate content (i.e., sexual, aggressive, and mature themes), making therapist screening and caregiver education essential to the management and proper utilization of EG in the home (AACAP, 2020). For children with ASD, it is also important to consider a child's developmental age and cognitive capabilities when implementing EG, further supporting the need for caregiver and clinician education regarding EG content.

It is recommended that any game implemented for therapeutic use should first be screened by the therapist (or caregiver) to ensure appropriate content. The screening process also permits time for the therapist to ensure that the game addresses the therapeutic goal. Screening of the EG also allocates time for the therapist to gain some mastery, reducing technical challenges when implementing the game. Ultimately, it is imperative that a therapist be diligent and make mindful choices when implementing EG for children with ASD. Collaboration with and education of caregivers is the key to ensuring that benefits are maintained, and risks are diminished.

Future research should include larger sample sizes, higher inclusion of female participants, long-term follow-up periods, and randomized controlled trial designs. There is a need to research the implications of more contemporary and commercially available EG to provide the most up-to-date evidence and allow feasible transmission into clinical practice. In the long term, it would be ideal for clinicians to collaborate with EG software developers to create well-designed therapeutic games for commercial availability to increase accessibility.

In conclusion, EG has emerged as a potentially innovative therapeutic tool to engage children with ASD in efficacious play-based therapy. Due to the novelty and rapidly evolving nature of EG, current evidence can be challenging for therapists and caregivers to interpret into implementable guidelines. The findings of this review comprehensively evaluated the advantages and disadvantages of utilizing EG to target specific client goals for children with ASD and provided up-to-date practical recommendations for clinicians and caregivers.

Authors' contribution

Conception and design of study: C.C; data collection: C.C, B.S; Data analysis and/or interpretation: C.C, B.S; Drafting of manuscript and/or critical revision: C.C, B.S, B.C; Approval of final version of manuscript: C.C, B.S, B.C.

Conflict of interests

Authors report no conflict of interest.

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