Supplementary appendix

Supplementary Table 1. Search strategies

Database	Search strategy	Limits / Filters
Embase	('attention deficit hyperactivity disorder'/exp OR 'attention deficit hyperactivity disorder':ti,ab,kw OR 'attention-deficit/hyperactivity disorder':ti,ab,kw OR adhd:ti,ab,kw OR 'attention deficit disorder':ti,ab,kw) AND ('virtual reality'/exp OR 'virtual reality':ti,ab,kw OR vr:ti,ab,kw OR 'immersive virtual environment':ti,ab,kw OR 'virtual environment':ti,ab,kw OR exergam*:ti,ab,kw OR 'serious game*':ti,ab,kw) AND (intervention:ti,ab,kw OR therapy:ti,ab,kw OR training:ti,ab,kw OR program:ti,ab,kw OR treatment:ti,ab,kw)	Humans, English
MEDLINE	("attention deficit hyperactivity disorder"[Title/Abstract] OR "attention-deficit/hyperactivity disorder"[Title/Abstract] OR ADHD[Title/Abstract] OR "attention deficit disorder"[Title/Abstract]) AND ("virtual reality"[Title/Abstract] OR VR[Title/Abstract] OR "immersive virtual environment"[Title/Abstract] OR "virtual environment"[Title/Abstract] OR exergam*[Title/Abstract] OR "serious game*"[Title/Abstract]) AND (intervention[Title/Abstract] OR therapy[Title/Abstract] OR training[Title/Abstract] OR program[Title/Abstract] OR treatment[Title/Abstract])	Humans, English
PsycINFO	(ADHD OR "attention deficit hyperactivity disorder" OR "attention-deficit/hyperactivity disorder" OR "attention deficit disorder") AND ("virtual reality" OR VR OR "immersive virtual environment" OR "virtual environment" OR exergam* OR "serious game*") AND (intervention OR therapy OR training OR program OR treatment)	Humans, English
PubMed	("attention deficit hyperactivity disorder"[Title/Abstract] OR "attention-deficit/hyperactivity disorder"[Title/Abstract] OR ADHD[Title/Abstract] OR "attention deficit disorder"[Title/Abstract]) AND ("virtual reality"[Title/Abstract] OR VR[Title/Abstract] OR "immersive virtual environment"[Title/Abstract] OR "virtual environment"[Title/Abstract] OR exergam*[Title/Abstract] OR "serious game*"[Title/Abstract]) AND (intervention[Title/Abstract] OR therapy[Title/Abstract] OR training[Title/Abstract] OR program[Title/Abstract] OR treatment[Title/Abstract])	Humans, English
Scopus	TITLE-ABS-KEY (ADHD OR "attention deficit hyperactivity disorder" OR "attention-deficit/hyperactivity disorder" OR "attention deficit disorder") AND TITLE-ABS-KEY ("virtual reality" OR VR OR "immersive virtual environment" OR "virtual environment" OR exergam* OR "serious game*") AND TITLE-ABS-KEY (intervention OR therapy OR training OR program OR treatment)	Humans, English
Web of Science	TS= (ADHD OR "attention deficit hyperactivity disorder" OR "attention-deficit/hyperactivity disorder" OR "attention deficit disorder") AND TS= ("virtual reality" OR VR OR "immersive virtual environment" OR "virtual environment" OR exergam* OR "serious game*") AND TS= (intervention OR therapy OR training OR program OR treatment)	Humans, English

Study Protocol

1. Background and Objectives

This study aims to systematically evaluate the effects of virtual reality (VR) interventions on individuals with Attention-Deficit/Hyperactivity Disorder (ADHD), focusing on improvements in cognitive performance, executive function, core symptoms, and motor abilities. By synthesizing current evidence, the study seeks to clarify the efficacy, feasibility, and potential limitations of VR interventions and provide guidance for future large-scale clinical research.

2. Study Design

This research is a systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency, reproducibility, and methodological rigor. A detailed study protocol is provided in the appendix.

3. Search Strategy

Search period: October 2025

Databases: PubMed, Web of Science, Scopus, Embase, MEDLINE, PsycINFO

Scope: Peer-reviewed studies published in English from the earliest available date of each database

Keywords: Terms related to ADHD, virtual reality, and intervention combined using Boolean operators (see Supplementary Table 1)

Supplementary search: Reference lists of included studies and relevant systematic reviews were manually screened

4. Eligibility Criteria

Inclusion criteria:

Participants: Individuals diagnosed with ADHD or hyperkinetic disorder based on DSM-IV, DSM-5, or ICD-10 criteria, or exhibiting clinically relevant ADHD symptoms. All ages (children, adolescents, adults) were included, with clearly reported age information.

Interventions: VR-based non-pharmacological interventions targeting behavioral, cognitive, executive, or motor outcomes.

Study design: Randomized controlled trials (RCTs), quasi-experimental studies, or open-label trials. Control conditions included waitlist, treatment-as-usual (TAU), placebo, pharmacological intervention, or alternative non-pharmacological interventions. Single-group studies or case studies were included if pre- and post-intervention assessment data were reported.

Exclusion criteria:

Interventions primarily involving pharmacological treatment, dietary supplementation, or homeopathy.

Combined VR and pharmacological or psychological interventions, unless the VR component was clearly described and aligned with the review objectives.

Non-English publications or studies reporting only neurophysiological or neurobiological outcomes without behavioral or functional assessments.

5. Study Selection and Data Extraction

Screening: Titles and abstracts were independently screened by two reviewers; full texts of potentially eligible studies were further evaluated. Discrepancies were resolved through discussion or adjudicated by a third reviewer.

Data extraction: A standardized form was used to record study characteristics, including authorship, year, country, sample size, participant demographics, diagnostic criteria, study design, VR intervention type, duration, frequency, setting, control conditions, and primary outcomes (attention, core ADHD symptoms, working memory, and other neuropsychological measures). Two reviewers independently extracted data, with discrepancies resolved through discussion or third-party adjudication.

6. Data Synthesis and Quality Assessment

Due to heterogeneity in interventions and outcomes, a narrative synthesis approach was used.

Risk of bias was assessed using Joanna Briggs Institute (JBI) critical appraisal checklists appropriate for each study design, evaluating study design, sampling, outcome measurement, statistical analysis, and reporting. Two independent reviewers conducted the assessment, resolving discrepancies through discussion or third-party adjudication.

7. Expected Outcomes and Significance

This review will provide a systematic synthesis of VR intervention effects in individuals with ADHD, assessing efficacy and feasibility. The findings will inform future large-scale, high-quality RCTs and guide clinical implementation of VR intervention.

Supplementary Table 2. Risk of bias assessment for individual randomized controlled trials, as assessed by the JBI Critical Appraisal Checklist for Randomized Controlled Trials
'Unclear' denotes not reported. Questions are as follows:

1.Was true randomization used for assignment of participants to treatment groups?
2.Was allocation to treatment groups concealed?
3.Were treatment groups similar at baseline?
4.Were participants blind to treatment assignment?
5.Were those delivering treatment blind to treatment assignment?
6.Were outcome assessors blind to treatment assignment?
7.Were treatment groups treated identically other than the intervention of interest?
8.Was follow-up complete, and if not, were differences between groups in terms of follow-up adequately described and analyzed?
9.Were participants analyzed in the groups to which they were randomized (intention-to-treat analysis)?
10.Were outcomes measured in the same way for treatment groups?
11.Were outcomes measured in a reliable and valid manner?
12.Was appropriate statistical analysis used?
13.Was the trial design appropriate and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?

	Question												
Author (year)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Cunha et al. (2023)	Yes	Unclear	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes
Cho et al. (2004)	Yes	Unclear	Unclear	No	No	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Martin-Moratinos et al. (2025)	Yes	Unclear	Yes	No	No	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Schena et al. (2023)	Yes	Unclear	Unclear	No	No	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Cho et al. (2002)	Yes	Unclear	No	No	No	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Benzing et al. (2019)	Yes	No	Yes	No	No	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Ji et al. (2023)	Yes	Unclear	Yes	No	No	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Wong et al. (2024)	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Frolli et al. (2022)	Yes	Unclear	Yes	No	No	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Hudak et al. (2017)	Yes	Unclear	Yes	No	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes	Yes
Bioulac et al. (2018)	Yes	Unclear	No	No	No	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes	Yes

Supplementary Table 3. Risk of bias assessment for individual quasi-experimental studies, as assessed by the JBI Critical Appraisal Checklist for Quasi-Experimental Studies. 'Unclear' denotes not reported. Questions are as follows:

1. Is it clear in the study what is the "cause" and what is the "effect" (i.e., temporal precedence is established)?
2. Was there a control group?
3. Were participants included in any comparisons similar?
4. Were participants included in any comparisons receiving similar treatment/care other than the intervention of interest?
5. Were there multiple measurements of the outcome, both pre- and post-intervention/exposure?
6. Were the outcomes of participants included in any comparisons measured in the same way?
7. Were outcomes measured in a reliable way?
8. Was follow-up complete, and if not, were differences between groups in terms of follow-up adequately described and analyzed?
9. Was appropriate statistical analysis used?

	Question								
Author (year)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Lee et al. (2001)	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
Oh et al. (2022)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Kim et al. (2024)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kim et al. (2020)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tabrizi et al. (2020)	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
De Luca et al. (2024)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes
Fang et al. (2025)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ou et al. (2020)	Yes	No	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Shema et al. (2018)	Yes	No	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Selaskowski et al. (2023)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Cuber et al. (2024)	Yes	No	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes

Supplementary Table 4. Summary of Outcome Measures and Cognitive Effects in Included Studies

Author (year)	Outcome Measure	Attention-related Outcomes	Core ADHD Symptoms: Inattention / Hyperactivity-Impulsivity (IN/HY)	Working Memory Outcomes	Other Neuropsychological Outcomes
Cunha et al. (2023)	The Southwestern Assessment of Processing Speed (SWAPS); Wechsler Adult Intelligence Scale - third Edition（WAIS-III）	NR	NR	The intervention group showed significant improvement in processing speed and in the "spatial location" working memory test, while the control group showed no significant changes.	NR
Lee et al. (2001)	Continuous Performance Test, CPT	E: Significant reduction in errors of omission; Significant reduction in errors of commission; C: No significant changes in the control group	NR	NR	E: Reduced response sensitivity; C: No significant changes in the control group
Oh et al. (2022)	Sense of presence questionnaire (Witmer & Singer scale); EEG (Alpha, Beta, Delta, Gamma, Theta waves)	NR	NR	NR	E: Improved sense of presence ($p<0.05$); No significant EEG changes (all $p>0.05$); C: No significant changes in the control group
Cho et al. (2004)	Continuous Performance Test (CPT); Beta wave ratio (EEG)	Significant improvement in hits ($p<0.01$) and reduced omission errors ($p<0.01$); Reduced commission errors ($p<0.05$) and improved response bias; Both E1 group and the E2 group showed improvements in CPT scores; E1 group demonstrated a more pronounced improvement trend. C: No significant changes in the control group	NR	NR	Higher beta wave ratio only in E1 group ($p<0.01$);

Author (year)	Outcome Measure	Attention-related Outcomes	Core ADHD Symptoms: Inattention / Hyperactivity-Impulsivity (IN/HY)	Working Memory Outcomes	Other Neuropsychological Outcomes
Kim et al. (2024)	Advanced Test of Attention (ATA); Pulmonary Function Test (MIP, MEP, FEV1, FVC);	Significant reduction in ATA omission errors (p<0.001); C: Compared to the C group, the E group showed a significantly greater improvement.	NR	NR	Improved pulmonary function (MIP p<0.01, FVC p<0.05); C: No significant changes in the control group
Kim et al. (2020)	Advanced Test of Attention (ATA); Interactive Metronome (IM)	E: Significant reduction in omission errors (p<0.001); E: Reduced commission errors (p<0.01) C: Compared to the C group, the E group showed a significantly greater improvement. (p<0.001 vs control)	NR	NR	Both group Improved IM response time (hands/feet: p<0.001)
Martin-Moratinos et al. (2025)	Primary: Strengths and Difficulties Questionnaire (SDQ); Secondary: SNAP-IV, CPRS, BRIEF-2, CPT-3, Corsi cubes, CTMT-2	No significant differences in CPT-3 omissions	Trends of improvement in SNAP-IV inattention (p=0.12); Trends of improvement in SNAP-IV hyperactivity (p=0.08); Compared to the C group, the E group showed a significantly greater improvement. No significant differences in CPRS	Significant improvements in working memory (p=0.04), Compared to the C group, the E group showed a significantly greater improvement.	Significant improvements in: material organization (p=0.03), inhibition (p=0.05), set shifting (CTMT-2, p=0.04) Compared to the C group, the E group showed a significantly greater improvement.
Schena et al. (2023)	Conners-3 (ADHD symptoms) BIA (attention/impulsivity) Tower of London (executive functions)	Significant improvements in Auditory attention (BIA, p=0.001); The results for the control group have not yet been published.	Significant reduction in hyperactivity/impulsivity (p=0.03); Reduced impulsive behavior in BIA (p=0.045) Significant improvements in: Sustained attention (BIA, p=0.001) The results for the control group have not yet been published.	NR	Planning (TOL, p=0.013), Problem-solving (TOL, p=0.004) The results for the control group have not yet been published.
Tabrizi et al. (2020)	Memory Subscale of Wechsler's IQ Test; Raven's Colored IQ Test	NR	NR	Significant improvement in memory (p<0.05 E1 vs control; p<0.05 E1 vs E2)	NR

Author (year)	Outcome Measure	Attention-related Outcomes	Core ADHD Symptoms: Inattention / Hyperactivity-Impulsivity (IN/HY)	Working Memory Outcomes	Other Neuropsychological Outcomes
De Luca et al. (2024)	Standardized cognitive-behavioral tests (BIA, BVL， Tower of London test);Game performance and biofeedback data	Both two group Enhanced sustained auditory attention (BIA test, p=0.001) No statistically significant difference between groups	Significant reduction in hyperactivity/impulsivity symptoms (BIA test, p=0.03) Decreased impulsive behaviors (BIA subtest, p=0.045) No statistically significant difference between groups	NR	Planning Ability： Significant improvement in planning skills (Tower of London test, p=0.013) Problem-Solving： Marked enhancement in problem-solving performance (Tower of London test, p=0.004) No statistically significant difference between groups
Cho et al. (2002)	Continuous Performance Test, CPT	VR Group Showed Significant Increase in Correct Responses (p<0.001) and Reduced Omission Errors (p<0.01); VR Group Reduced Commission Errors (p<0.05) and Significantly Improved Response Bias (p<0.01)	NR	NR	VR Group Showed Significant Improvement in Perceptual Sensitivity (p<0.01);
Fang et a. (2025)	Behavior: SNAP-IV scale Inhibitory control: Stop-Signal Task, Inhibition Conflict Task, Simon Task	Stop-Signal Task: material rewards (F1=13.04, P=0.001), psychological rewards (F1=38.54, P<0.001), and their interaction (F1=4.47, P=0.04) all showed significant effects.	SNAP-IV: material rewards (F1=69.23, P<0.001), psychological rewards (F1=70.78, P<0.001), and their interaction (F1=23.85, P<0.001) all significantly improved ADHD-related symptoms.	NR	Inhibition Conflict Task: material rewards showed significant effects (F1=7.34, P=0.008). Simon Task: no significant effects reported.
Benzing et al. (2019)	DSM-IV-TR Symptom Scale T-scores, Conners-3 (ADHD symptoms) (parent ratings) Modified Simon Task (inhibition), Modified Flanker Task (switching), Color Span Backward Task (updating), German Motor Test	NR	The study used DSM-IV-TR Symptom Scale T-scores to assess ADHD severity, a significant effect was found on the total global index score (P = 0.022). No significant improvement (parent ratings, p>0.05)	NR	Inhibition (faster RTs, p=0.049, d=0.58); Switching (faster RTs, p=0.029, d=0.65); Motor abilities (total score improved, p=0.008, d=0.80) Compared to the C group, the E group showed a significantly greater improvement.

Author (year)	Outcome Measure	Attention-related Outcomes	Core ADHD Symptoms: Inattention / Hyperactivity-Impulsivity (IN/HY)	Working Memory Outcomes	Other Neuropsychological Outcomes
Ou et al. (2020)	TONI-4 (nonverbal intelligence); ATESC (attention test); WCST (executive function); SNAP-IV (parent-reported ADHD symptoms)	ATESC test showed improvements in all five attention dimensions, with notable gains in focused and sustained attention.	Reduced hyperactivity/impulsivity & defiance (SNAP-IV); Reduced inattention (SNAP-IV)	NR	Improved TONI-4; Mixed WCST results
Ji et al. (2023)	Go/No-go RT; N2 amplitude (ERP); FAIR attention test	E and C groups showed significant improvements in selective attention and sustained attention (all $P < 0.001$);	NR	NR	Self-regulation abilities measured by the FAIR test also improved significantly (E: $P = 0.02$; C: $P = 0.005$). Both two groups Reduced Go/No-go RT only E group Increased N2 amplitude
Shema et al. (2018)	Conners' Parent Rating Scale-Revised (CPRS-R); Cognition: NeuroTrax™ computerized neuropsychological tests, Color Trails Test; Dual-task walking: Gait analysis (walking speed, gait regularity, stride time variability)	No significant change in the computerized attention index score immediately after training ($p = 0.976$); Improvements in executive function (executive function index: $p = 0.042$, $d = 0.63$; Color Trails Test part 2 completion time: $p = 0.005$, $d = 0.89$; sequence errors: $p = 0.026$, $d = 0.71$)	Behavioral outcomes: Significant reduction in social problems immediately after training ($p = 0.047$, $d = 0.64$). Trends toward reduction in hyperactivity ($p = 0.074$, $d = 0.57$) and restless-impulsive behavior ($p = 0.055$, $d = 0.62$).	Significant improvement in memory index score immediately after training ($p = 0.001$, $d = 0.86$).	Step regularity increased from 0.49 ± 0.11 at baseline to 0.57 ± 0.09 post-training ($d = 0.77$, $p = 0.016$);No significant changes in cognitive task performance during dual-task walking, but trend toward improved content recall ($p = 0.096$, $d = 0.45$).
Wong et al. (2024)	Clinical psychologist-assessed social skills; Social Skills Improvement System Rating Scale (parent-rated); Behavior Rating Inventory of Executive Function (parent-rated); Simulator Sickness Questionnaire	NR	NR	NR	Both E1 and E2 group Significant improvement in social skills ($p<0.001$); Emotional control significantly improved ($p<0.001$); Self-control ($p<0.001$) and initiative ($p<0.001$) significantly improved; Compared to the E2 group, the E1 group showed a significantly greater improvement. C: No significant changes in the control group

Author (year)	Outcome Measure	Attention-related Outcomes	Core ADHD Symptoms: Inattention / Hyperactivity-Impulsivity (IN/HY)	Working Memory Outcomes	Other Neuropsychological Outcomes
Frolli et al. (2022)	90-item history knowledge test Motivation levels (qualitative)	NR	NR	NR	Both two groups showed significant improvement in accuracy after training (E: 78.94% vs C: 68.07%, $p<0.05$). The E group demonstrated significantly greater improvement than the C group ($p<0.05$). Children in the E group exhibited higher intrinsic motivation and engagement (qualitative observational findings).
Selaskowski et al. (2023)	CPT errors/reaction times; Gaze dwell times; EEG theta/beta ratio; Head actigraphy	More omission errors ($p=0.024$) and slower RTs ($p=0.044$) in E group; No group differences in commission errors	NR	NR	Both two groups Higher θ/β ratio during distraction ($p<0.001$); Elevated gaze distractibility ($p=0.004$); Increased head movements in E group ($p<0.001$);
Hudak et al. (2017)	Go/No-Go Task: N-back Task: Stop-Signal Task fNIRS Data:	Reduced reaction time variability (SDRT, $p=0.035$) C: No significant changes in the control group; Significant reduction in FA errors on Go/No-Go ($p=0.01$);	NR	NR	Significant increase in prefrontal O_2Hb ($p=0.005$); C: No significant changes in the control group
Bioulac et al. (2018)	ADHD-RS (parent version) Continuous Performance Test, CPT	E1 has significant Improvement in Correct Hits (E1, $p<0.0001$) Reduced Commission Errors (E1, $p=0.05$) vs. E2; Reduced Omissions ($p=0.03$) Comparable to E2;	E1: After the intervention, total ADHD-RS scores, inattention scores, and hyperactivity-impulsivity scores all decreased significantly, with improvements exceeding those of the E2 and C groups.	NR	NR

Author (year)	Outcome Measure	Attention-related Outcomes	Core ADHD Symptoms: Inattention / Hyperactivity-Impulsivity (IN/HY)	Working Memory Outcomes	Other Neuropsychological Outcomes
Cuber et al. (2024)	Subjective scales: Concentration, Motivation, Effort/Efficiency; Objective: Interaction data (keyboard/mouse)	Significant improvement in attention ($p<0.0001$, $d=3.04$)	NR	NR	Motivation ($p=0.0001$, $d=1.25$); Efficiency ($p<0.0001$, $d=1.76$) significantly improved

Supplementary Table 5. Summary of Interventions and Procedures in Included Studies

Author (year)	Active Treatment Components	Specific Intervention Procedures
Cunha et al. (2023)	Cognitive Training	E: VR games-10 sessions with Enhance VR app (Whack-a-mole, Shuffled, Assembly, React, Memory Wall, Maestro) C: Passive control group – no intervention was provided during the study period.
Lee et al. (2001)	neurofeedback	E: VR Neurofeedback training-10 sessions in a virtual classroom using a head-mounted display (HMD) and head-tracking system. Real-time EEG processing provided positive feedback (e.g., advancing a dinosaur puzzle) whenever the participant's Beta waves (15–18 Hz) exceeded the daily baseline threshold. C: Passive control group – participants waited during the VR training period and completed pre- and post-assessments at the same time points as the intervention group.
Oh et al. (2022)	Cognitive Training	E: VR Cognitive Training – 8 sessions using a VR program developed with the Unreal Engine. The intervention involved behavioral inhibition training in a roller-coaster scenario, where participants had to shoot specific target balloons while ignoring distracting stimuli. C: Healthy control group – comprised of typically developing children who completed the same VR cognitive training as the experimental group.
Cho et al. (2004)	neurofeedback	E1 (VR group): VR Neurofeedback Training – 8 sessions over 2 weeks in a virtual classroom using a head-mounted display and head tracker. Real-time EEG processing reinforced Beta activity (15–18 Hz) to advance a dinosaur puzzle task. E2 (non-VR group): Non-VR Neurofeedback Training – identical neurofeedback protocol as the VR group, but delivered on a standard computer monitor with a fixed viewpoint. C: Passive control group – received no intervention during the training period and completed only pre- and post-assessments.
Kim et al. (2024)	biofeedback	E: VR Breathing Training Games (Rocket, Candle, Food) – 8 sessions over 4 weeks, combined with a psychomotor program C: Psychomotor program only
Kim et al. (2020)	Cognitive Training	E: Mixed Reality Eye-Contact Game C: No intervention
Martin-Moratinos et al. (2025)	cognitive training +behavioral therapy	E: MOON serious video game – 20 sessions (10 face-to-face in hospital + 10 web-based at home). Games targeted sustained attention & inhibition (Smasher), planning (Teka Teki), visuospatial skills (Kuburi), reasoning (Chess), and working memory (Enigma). Features included adaptive difficulty, star-based rewards, music modulation, and researcher supervision. VR used for >12 years (PlayStation VR), computer for 7–11 years. C: Pharmacological treatment + psychoeducation – no video game.
Schena et al. (2023)	cognitive training +behavioral therapy	E: IAmHero serious game in VR – 10 sessions (30 min/session, once/week for 6 months). Games targeted auditory attention & planning (Topological Categories), impulse control & inhibition (Infinite Runner), and planning & problem-solving (Space Coding). Platform: Oculus Quest 2. Therapist-supervised, integrated with conventional therapy. C: Conventional therapy only – speech/psychomotor therapy, 2 sessions/week.
Tabrizi et al. (2020)	Cognitive Training	E1: VR cognitive training – 10 sessions (3 min/session). Tasks involved target image recognition with audiovisual distractors on Samsung VR Box + laptop, with progressive difficulty (very easy → very difficult). E2: Medication – Ritalin/atomoxetine/dexamphetamine. C: No intervention.

Author (year)	Active Treatment Components	Specific Intervention Procedures
De Luca et al. (2024)	cognitive training +behavioral therapy	E: Serious game intervention based on Extended Reality (XR), consisting of three types of games (topological classification, endless runner, and planning). The system integrates HTC VIVE, Kinect, and biofeedback (EEG, heart rate, and skin conductance). Conducted multiple times per week over a period of 6 months. C: Traditional behavioral and cognitive training.
Cho et al. (2002)	Cognitive Training	E: Immersive VR cognitive training involving comparison and sustained attention tasks, using a head-mounted display (HMD) and head tracker. Each session lasted 20 minutes, with a total of 8 sessions over 2 weeks. C: Non-VR group performed the same tasks on a screen; control group received no intervention.
Fang et al. (2025)	Cognitive Training	E: VR-based cognitive-motor training with different reward feedback (coins/tokens + verbal encouragement/badges) C: VR training without reward feedback
Benzing et al. (2019)	Cognitive Training	E: Exergaming using Xbox Kinect (e.g., *Shape Up*) to train body coordination and executive functions, 30 minutes per session, 3 times per week, for 8 weeks. C: Waitlist control group, no intervention.
Ou et al. (2020)	Cognitive Training	E: Immersive VR coordination training games (*Fishing Master*, *Fruit Train*, *Ocean Manager*), using HTC VIVE, 40 minutes per session, 3 times per week, for 3 months. C: No control group; single-group pre–post design.
Ji et al. (2023)	Cognitive Training	E: Exergaming Training - 12 sessions (3 days/week for 4 weeks), 50 min/session with ExerHeart device & Alchemist's Treasure game (Running/Jumping on a mat to control an avatar, avoiding obstacles, and collecting items) C: Aerobic Exercise - 12 sessions (3 days/week for 4 weeks), 50 min/session with Stationary bicycle (Cycling at 60-80% of heart rate reserve)
Shema et al. (2018)	Cognitive Training	E: VR-augmented treadmill training (avoiding virtual obstacles while walking)
Wong et al. (2024)	behavioral therapy	E1: VR-based Social Skills Training - 12 sessions over 3 weeks, 20 min/session with Head-Mounted Display & custom VR scenarios (Practicing social interactions in simulated real-life scenarios: classroom/playground, mass transit, supermarket/restaurant) E2: Traditional Social Skills Training - 12 sessions over 3 weeks, 20 min/session with Educator-led program (Role-playing and didactic instruction on self-introduction, listening, sharing, and empathy) C: Waitlist Control - No intervention
Frolli et al. (2022)	behavioral therapy	E: VR-based Learning - Training over 4 months with 3D viewer & interactive videos (Watching history topics presented in 3D immersive videos) C: Traditional Learning - Training over 4 months with Specialized educator (Individual reading and memorization of history topics with educator feedback)
Selaskowski et al. (2023)	neurofeedback	E: ADHD VR Neurofeedback training C: HC VR Neurofeedback training
Hudak et al. (2017)	neurofeedback	E: fNIRS-NF + VR In a VR classroom, participants controlled the brightness of the light by regulating O_2Hb levels in the dlPFC. C: EMG-BF + VR In the same VR classroom, participants controlled the brightness of the light by regulating shoulder muscle activity.Served as an active control to account for nonspecific effects.

Author (year)	Active Treatment Components	Specific Intervention Procedures
Bioulac et al. (2018)	cognitive training	E1: VR Cognitive Remediation Conducted a letter detection task in a VR classroom while resisting distractors. E2: Pharmacological Treatment Methylphenidate administration, with dosage adjusted based on clinical response. C: Supportive Psychotherapy Individual psychotherapy serving as a placebo control to account for nonspecific effects.
Cuber et al. (2024)	behavioral therapy	E: VR environment (cabin + noise-canceling headphones) vs. Baseline (usual study environment)