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Online training programs for adults with disabilities: a systematic review

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In the last decade, there has been an increase in online or digital technology-based training. Online training offers promising, accessible learning opportunities for everyone. However, few studies have specifically evaluated the scope of this training for adults with disabilities. The primary aim of this study is to conduct a systematic review of this topic. This involves evaluating the literature, including the methodology used, the variables analyzed, and the characteristics of the training program, as well as identifying gaps in the research. Our findings show that the number of publications is low, although there has been an increase in recent years. Furthermore, it is critical to highlight the importance of an intervention methodology grounded in scientific research and the evaluation of implementation fidelity. In general, online programs improve a variety of trained skills. Expanding interventions within this population, mainly targeting adult women with disabilities, is essential to promote equity and inclusivity in lifelong learning.

Introduction

The advancement of Information and Communication Technologies (ICT) has greatly impacted society, transforming the way we live, work, and learn. In this last aspect, ICT has become a fundamental support, opening new possibilities and opportunities. Thus, in recent decades, online education has experienced significant growth (Karademir Coşkun & Alper, 2019; Wallace-Spurgin, 2020). Educational platforms, online training courses, and digital resources are presented as globally accessible learning opportunities. However, is online education truly accessible to everyone, including adults with disabilities? And is the provision of this training sufficient for this group? Although ICTs offer significant opportunities, access to online training is not always equitable, presenting challenges particularly for adults with disabilities.

According to the World Health Organization (2023), it is estimated that approximately 1.3 billion people worldwide have some form of disability, accounting for 16% of the global population. In Europe, the Council of the European Union (2022) reports that 101 million adults are living with disabilities, representing 27% of the adult population. They further note that the age groups most affected are those between 45 and 64 years old, as well as those over 65. Additionally, within the European Union, the prevalence of disabilities is higher among women, at 29.5%, compared to 24.4% among men (Council of the European Union, 2022).

We must keep in mind that people with disabilities encounter a multitude of challenges. Compared to those without disabilities, they experience higher rates of unemployment, increased

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risk of poverty or social exclusion, greater susceptibility to violence and abuse, poorer academic performance, and a higher school dropout rate (Council of the European Union, 2022). In this context, online education could help mitigate some of these issues, potentially improving the quality of life for people with disabilities and fostering their social integration. Furthermore, Article 24.5 of the Convention on the Rights of Persons with Disabilities (Instrument of Ratification of the CRPC, December 13, 2006, April 21, 2008) explicitly recognizes the right to education for persons with disabilities:

> States Parties shall ensure that persons with disabilities have general access to higher education, vocational training, adult education, and lifelong learning without discrimination and on an equal basis with others. To this end, States Parties will ensure that reasonable adjustments are made for persons with disabilities (Article 24.5, p. 96)

In this regard, online training could offer several advantages over face-to-face training for people with disabilities. For instance, its adaptability allows for training to be personalized based on the individual's profile, learning style, and specific needs (Aeiadand & Meziane, 2019). Online training also provides flexibility in terms of when the training is accessed, enabling learners to set their own pace, and thereby fostering greater autonomy in learning. Another key feature of online education is its accessibility, both in terms of time and location, which allows learners to access training from any place (Herrera et al., 2015). Additionally, some studies (e.g., Biggs & Tang, 2011) have noted that for individuals with autism spectrum disorder (ASD), asynchronous participation in discussions can reduce stress by allowing them to respond at their own pace.

Considering these advantages, there has recently been a considerable increase in online or virtual learning environments developed specifically for individuals with special educational needs (Ozdemir et al., 2019). These environments include a range of tools such as online learning platforms, collaborative learning environments, virtual classrooms, 3D simulators, and virtual environments, as well as virtual reality (VR) and augmented reality (AR). These emerging technologies are being explored for their potential to enhance the educational experience by offering immersive simulations and more engaging learning environments. For instance, Contreras-Ortiz et al. (2023) note that the technologies like VR, AR, and mobile applications are particularly implemented with individuals with autism, alongside other utilized environments.

These educational environments are versatile, enabling the development of a broad range of skills, including academic, social, emotional, communication, personal autonomy, and cognitive skills, among others. For example, Howard and Gutworth (2020) emphasize the potential of virtual reality (VR) to enhance social and emotional skills in individuals with autism.

However, key questions remain: What components or elements should a learning environment include to ensure meaningful learning for people with disabilities? Additionally, what skills must individuals possess to effectively interact with online environments?

Research by Meyers and Bagnall (2015) and Downing (2014), which reflects the perceptions of students with autism, underscores the necessity for clear instructions and presentation of material. They recommend minimizing the number of resources and links available. In line with these findings, it is crucial to design simpler environments that feature clear, specific, simple, literal, and easy-to-follow instructions (Contreras-Ortiz et al., 2023).

Adams et al. (2019) identified several barriers and facilitators in the learning experience of university students with autism. Among the barriers, notable issues include the overwhelming amount of information on a page, the need for immediate answers to their questions, difficulty planning the schedule, excessive workloads, and pressing deadlines. Conversely, facilitators include the ability to pause and replay videos, flexible scheduling, prompt responses to inquiries, availability of evaluation rubrics, and a detailed timetable. The authors emphasize the importance of interaction and creating collaborative learning communities. However, they caution that the nature and frequency of these interactions can either hinder or help students with autism, thus underscoring the need to establish a functional virtual community (Garrison, 2017). Additional studies (Contreras-Ortiz et al., 2023) highlight essential characteristics of an effective online environment. These environments should be dynamic, incorporating a variety of resources and a robust learning support system, and must adapt to meet individual needs and preferences (Brown, 2000). For individuals with ASD, it is crucial to include visual elements such as videos and images, utilize authentic images, provide specific instructions, and employ a natural voice in presentations. In addition, instructional strategies should incorporate positive reinforcements, gradually increase the difficulty of activities, and ensure thorough supervision and monitoring throughout the teaching-learning process (Contreras-Ortiz et al., 2023). Acosta et al. (2020) also provide recommendations for creating accessible and inclusive online content. These guidelines align with the Authoring Tools Accessibility Guidelines (ATAG) 2.0 of the World Wide Web Consortium. They design online training programs for people of any age with disabilities. Ultimately, any intervention or training must be tailored to the specific needs of its target population.

Key skills necessary for successful online learning include self-regulation, self-discipline, time management, organization, and self-evaluation. These skills, crucial for engagement with learning content, are highlighted in a review by Kauffman (2015) and further supported by research from Serdyukov and Hill (2013). Additionally, digital competence is essential for effective interaction with online platforms and resources, particularly for adults with disabilities.

Despite a significant increase over the last decade in the number of publications on interventions and training through online environments, VR/AR, etc., across various population groups (e.g., Dechsling et al., 2020; Mesa-Gresa et al., 2018; Lorenzo et al., 2018), and the positive outcomes from the implementation of ICT in training processes (Contreras-Ortiz et al., 2023), a critical question remains: What do we really know about the online training of adults with disabilities?

Several review studies have investigated virtual and augmented reality (VR/AR) in educational interventions for individuals with autism. For example, studies conducted by Mesa-Gresa et al. (2018) and Lorenzo et al. (2018) have primarily focused on children with autism. Expanding this demographic scope, the research by Dechsling et al. (2022) reviewed the literature on autism interventions using VR/AR across different age groups. Their analysis of 49 articles found that only one study (Amaral et al., 2018) included participants over 31, with no studies involving individuals over 40. Similarly, Contreras-Ortiz et al. (2023) reviewed e-learning ecosystems for people with ASD, observing a notable gap in research focused on adults. An e-learning ecosystem integrates all essential components needed to implement an online learning system, as discussed in studies by Ezzahraa et al. (2020) and Luna-Encalada et al. (2021).

To our knowledge, no studies from previous reviews have specifically aimed to analyze online training for adults with disabilities. Given the rapid development of online learning and the notable lack of information about this demographic, there is a clear justification for conducting a review to systematically map and evaluate the existing research in this field.

Table 1 Comparative IRR test scores and κ statistic.

Categories	First IRR		Second IRR		Third IRR	
	N studies	Percent	*N* studies	Percent	*N* studies	Percent
Total items coded individually	161	100	160	100	160	100
Number of studies included in the screening*	15		69		62	
Number of studies excluded in the screening*	307		251		258	
Number of agreements included and excluded*	154	95.65	150	93.17	160	100
Number of studies that required discussion	7	4.35	10	6.25	0	-
Lack of agreement after discussion	0		0		0	
Agreement after arbitration	NA	NA	NA	NA	NA	NA
κ Statistic [a]	0.74		0.80		1	

Note: *IRR* interrater reliability.
[a]κ statistic was calculated based upon the number of inclusions and exclusions after the initial screening decision and before reconciliation (Cohen' Kappa).
*Made by the two judges.

The aim of this review is to provide a comprehensive summary of studies that have utilized online training formats for adults with disabilities. This involves evaluating the literature, including the methodologies used, the variables analyzed, and the characteristics of the training program. Additionally, this review seeks to identify any research gaps in the existing literature.

Material and methods

A systematic review was conducted following the protocol "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" PRISMA protocol version 2020 (Page et al., 2021). This protocol includes four phases: identification, selection, eligibility, and inclusion (Urrútia & Bonfill, 2010).

Procedure

Search strategy. We searched for relevant documents related to our object of study in two electronic databases: SCOPUS and WoS. The search was carried out by topic in the last ten years (January 2014 to January 2024). We conducted the search using a combination of keywords with different Boolean operators. Quotation marks ("") were used to find documents that contained the specific concept related to our study. Likewise, the operator "OR" expanded the search with synonyms for the keywords. We also used the asterisk (*) after the root of a word to search for all documents containing that word and its possible endings. Finally, to find only the documents containing the key concepts (or set of concepts simultaneously), the logical operator joined these "AND." The first topic involved words related to online education. We use ("e-learning" OR "online education" OR "distance learning" OR "virtual learning" OR "distance education" OR "online learning" OR "online course" OR "remote education" OR "remote learning" OR "virtual education" OR "virtual course" OR "web-based learning" OR "web-based training" OR "web-based education" OR "online training program"). The second topic was related to the age or population that is the object of our study. The words used were ("adults" OR "adulthood" OR "Elderly" OR "Age group: 18 and older"). The last topic referred to the disabled group. This dernier topic was as follows: ("disabilities" OR "disabled" OR "impairments" OR "special needs" OR "neurodevelopmental disorders" OR "intellectual disorders" OR "intellectual disabilities" OR "communication disorders" OR "autism spectrum disorder" OR "attention-deficit/hyperactivity disorder" OR "specific learning disorders" OR "motor disorders" OR "physically challenged" OR "physical disabilities" OR "sensory impairments" OR "chronic health conditions" OR "autis*" OR "sensory disabilities" OR "syndrome down").

Inclusion and exclusion criteria. For an article to be included, it had to: (1) address directly online training aimed at adults with disabilities; (2) the sample study had to be people with disabilities; (3) were published in the last ten years (from January 2014 to October 2023); (4) were studied from any country (published in English or Spanish). Exclusion criteria were: (1) Gray literature (dissertations, posters, etc.); and (2) studies not reporting results about the online program.

Selection process. The search identified 535 articles (105 from WoS and 430 from SCOPUS). All documents were exported to the Rayyan tool for subsequent classification and selection. Of the 535 papers found, we removed 54 duplicate documents. The titles and abstracts of the 481 papers found were then examined. To ensure fairness and improve the reliability of our selection process, we employed a method known as blind selection, as described by Ouzzani et al. (2016). This method allowed multiple judges to rank documents independently without being influenced by the ratings of others. Our selection process followed a structured approach inspired by Belur et al. (2021), which involves dividing screening into multiple stages. In line, each author screened the documents found in three different stages: in the first stage, each author reviewed 161 papers, and in the second and third stages, reviewed 160 articles, respectively. During this phase, disagreements arose that were discussed by the authors, reaching a justified agreement on selecting the article for the next phase. This iterative method allows judges to refine their understanding of the inclusion criteria and improve consensus at each stage, ultimately improving the reliability of the IRR index. After completing the blind selection, we collected the rankings of all judges and transferred them to a database. Subsequently, we calculated inter-rater reliability indices (IRR) to assess the consistency of the judgments. IRR indices were calculated using Coen's Kappa, achieving 0.74 in the first stage, 0.80 in the second stage, and a perfect score of 1 in the last stage (see Table 1).

After screening, 408 records were eliminated for not meeting the inclusion criteria. The remaining 73 documents were assessed for the eligibility phase. For this purpose, the full texts were obtained. The process was carried out through a collaborative effort between the two authors, so the articles were distributed equally. Next, each author reviewed the work done by her colleague to check and verify that the articles met the criteria. If there was any disagreement, it was analyzed and discussed. Finally, 16 articles are selected for review once the inclusion and exclusion criteria have been examined and applied. Fifty-nine articles were excluded during this phase for the following reasons: (1) The purpose of the training in these studies was solely rehabilitative rather than educational. These interventions focused on recovering or improving skills and functions physically lost or impaired by illness or injury rather than educational interventions aimed at enhancing knowledge and skills in a health

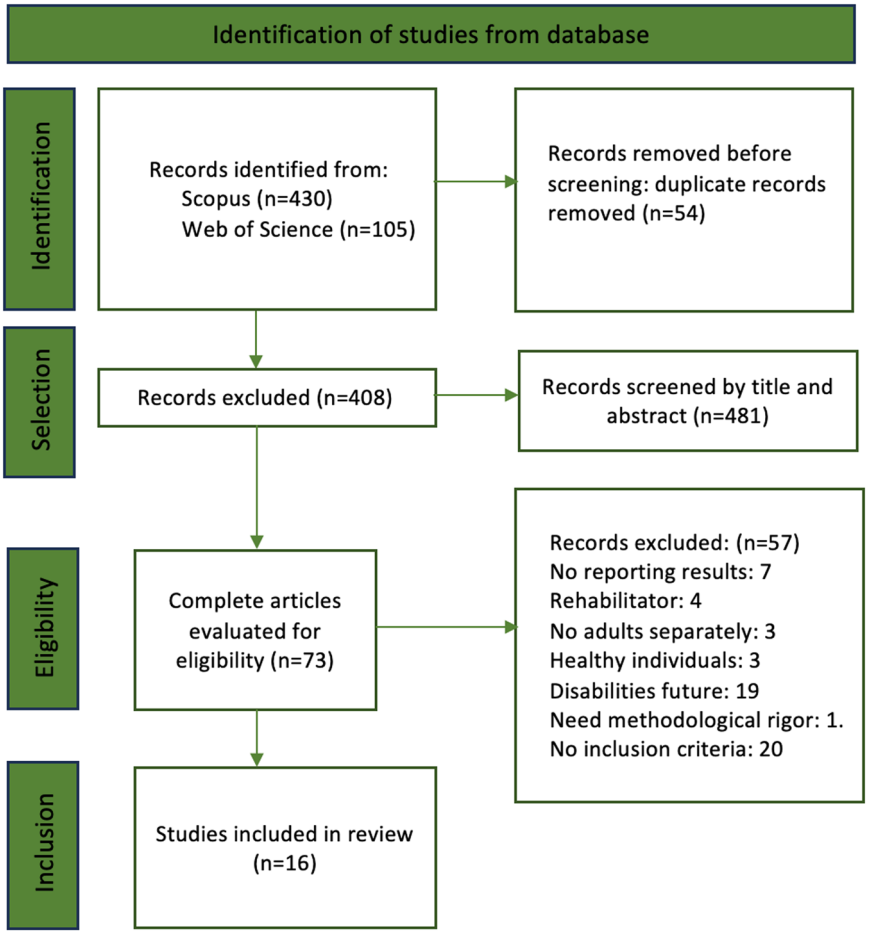

Fig. 1 PRISMA flow Diagram (Page et al., 2021). Data extraction procedure in four phases: identification, selection, eligibility and inclusion.

context or other contexts. For example, studies involving the use of a robot connected to an arm, intended to improve mobility after an injury, were excluded. (2) Some studies included both minors and adults in their sample, but presented the results without distinguishing between different age groups. (3) Despite targeting people with disabilities, certain training programs were tested on healthy individuals. (4) Some studies included diseases that could potentially lead to disabilities in the future, but did not necessarily involve individuals with current disabilities. (5) Studies lacking comprehensive explanations of their research design (including sampling methods, description of the sample, instruments, procedures, and data analysis) were excluded from consideration. This decision was made with the recognition that a thorough explanation of these aspects is crucial for maintaining rigor.

Figure 1 offers a visual representation of the process conducted in accordance with the PRISMA protocol.

Document coding. The 16 scientific articles underwent analysis and coding based on the following criteria: (1) Participant information, including age, number of participants, gender, and type of disabilities. (2) Study details, encompassing authors, year of publication, objectives, methodology, measurements, instruments, analysis, and principal findings. (3) Program specifics, covering objectives, methodology, and duration.

Results

Following the PRISMA protocol, 16 scientific articles were included and analyzed based on criteria encompassing the study participants' characteristics, characteristics of the studies, and program attributes, as previously mentioned.

About the characteristics of the study participants (see Table 2), most studies provide specific details on age, sex, and type of disability. The studies encompass a range of age groups, with some focusing on specific development stages (Arachchi et al., 2021; Bruce et al., 2017; Garcia et al., 2023; Mead et al., 2023). Participant numbers vary significantly, from a single participant in the study by Silva de Souza et al. (2018) to 5586 participants in Mead et al. (2023), bringing the total number of participants across all studies to 6129. Generally, the sample sizes are small, with most studies involving no more than 128 participants, except for Mead et al. (2023), which analyzed institutional accommodations for students with disabilities using existing registered data. The gender distribution across the studies appears relatively balanced, although some studies show slight variations toward one gender. Now, if we narrow our focus to the subset of individuals with disabilities within the sample under consideration, excluding the study by Mead et al. (2023), where the large sample skews the overall statistics, we find that 55.83% of participants are male, while 44.15% are female among those with disabilities. The studies also cover various types of disabilities: two concentrate on intellectual disabilities (Arachchi et al., 2021; St. John et al., 2022), two on autism spectrum disorder (De Felice et al., 2023; Garcia et al., 2023), two on Attention Deficit/Hyperactivity Disorder (Bruce et al., 2017; Moëll et al., 2015) and two on visually impairments (Güdül Öz & Yangın, 2021; Silva de Souza et al., 2018), with others addressing additional disabilities.

Regarding the characteristics of the studies (see Table 3), it is observed that while the aims of the studies are diverse, some

Table 2 Summary of participant characteristics by study.

Study	Age range (mean age)	N*; gender	Type of disability
Arachchi et al. (2021)	18–30 (M = 19.20)	10; 5 males and 5 females	Intellectual and Developmental Disabilities
Ayuso and Santiago (2022)	18–43 (M = 30,3)	10; 6 males and 4 females	Intellectual disability level
Bruce et al. (2017)	18–25 (G1: M = 22.2; G2: M = 19.2)	25; 18 males and 7 females	Attention Deficit / Hyperactivity disorder
Busse et al. (2022)	≥ 18 (M = 60.9)	21; 6 males and 15 females	Progressive Multiple Sclerosis
Chiu et al. (2023)	≥ 65 (M = 80.35)	60; 34 males and 26 females; 30 Virtual Reality group and control group	Cognitive impairment and dementia
Curtiss et al. (2023)	No data	11 (no date gender)	No data (it assumes people with and without intellectual disabilities)
De Felice et al. (2023)	18–65 (AG: M = 27,79; NG: M = 29,85)	128; 51 males, 66 female and 10 nonbinaries; 61 autistic (28; 24) and 67 no autistic (23; 42)	Autism Spectrum Disorder
Fjellström et al. (2022)	18–60 (M = 36.2)	22; 12 males and 10 females	Intellectual disability
Garcia et al. (2023)	18–35 (M = 26,6)	13; 10 males and 3 females	Autism Spectrum Disorder
Güdül Öz and Yangın (2021)	18–65 (M = 25,77)	35; 23 males and 12 females	Visual Impairments
Mead et al. (2023)	18–29 (M = 19 in person; M = 25 online)	5.586; 1756 males y 3830 females; 2908 face-to-face end 2678 online	Learning disability (including ADD/ADHD) or mental health/psychological disability and other disabilities
Moëll et al. (2015)	≥ 18 (M = 36.6)	57; 13 males and 44 females; 29 experimental group and 28 control group	Attention Deficit / Hiperactivity disorder
Rimmer et al. (2022)	21–71 (M = 49)	53 (no date gender)	Physical disabilities
Silva de Souza et al. (2018)	33	1 male	Visual Impairments (wheelchair user)
St. John et al. (2022)	≥ 18 (M = 41.4)	27; 11 males, 15 females and 1 gender fluid	Intellectual disability level
Worobey et al. (2018)	>18	71; 58 males and 13 females; 10 in-person training, 39 web training and 20 waitlist control	Physical disability

Note. *Total number of participants.

common themes emerge. For instance, St. John et al. (2022) and Rimmer et al. (2022) focus on evaluating programs aimed at improving well-being, while Curtiss et al. (2023) and Güdül Öz and Yangın (2021) evaluate educational programs centered on sexuality education. Additionally, Fjellström et al. (2022) and Rimmer et al. (2022) both involve programs related to physical activity. All these articles commonly evaluate training programs designed for adults with disabilities. The methodologies employed across these studies vary, with 50% utilizing quantitative methods (e.g., Bruce et al., 2017; De Felice et al., 2023; Mead et al., 2023; Moëll et al., 2015; Worobey et al., 2018), 37.5% using mixed methods, and 12.5% adopting qualitative approaches. These studies assess the effectiveness of ICT-based training by analyzing improvements in various domains, including cognitive (e.g., Chiu et al., 2023; Moëll et al., 2015 and Worobey et al., 2018), physiological and physical activity (e.g., Busse et al., 2022; Fjellström et al., 2022; Rimmer et al., 2022; Silva de Souza et al., 2018), educational and behavioral (v.gr., Ayuso & Santiago, 2022; Bruce et al., 2017; Curtiss et al., 2023; García et al., 2023; Güdül Öz & Yangın, 2021; Moëll et al., 2015) and performance variables (Arachchi et al., 2021; De Felice et al., 2023; Mead et al., 2023). Additionally, several studies assess the feasibility, usability, satisfaction, and participants' perception of their experiences (e.g., Busse et al., 2022; Fjellström et al., 2022; Garcia et al., 2023; Güdül Öz & Yangın, 2021; Rimmer et al., 2022; St. John et al., 2022), while a few analyze implementation fidelity (e.g., Busse et al., 2022; Chiu et al., 2023; Garcia et al., 2023). A variety of tools, including scales, questionnaires, observations, and interviews, are employed, and analyses such as ANOVA and regression are commonly used (e.g., De Felice et al., 2023; Fjellström et al., 2022; Mead et al., 2023; Rimmer et al., 2022, Worobey et al., 2018). In qualitative studies, thematic and content analyses are prevalent (e.g., Curtiss et al., 2023; García et al., 2023; Silva de Souza et al., 2018; St. John et al., 2022).

Concerning the characteristics of the programs (see Table 4) and the main objectives pursued in the interventions, various focuses are evident. Some programs aim to improve specific skills such as danger perception and driving ability (Bruce et al., 2017) or cognitive skills (Chiu et al., 2023). Others provide knowledge on diverse topics, like effective web search techniques (Arachchi et al., 2021) or a broad range of content (De Felice et al., 2023). Regarding the intervention methodologies, many studies report that the programs often include support from professionals, researchers, or teachers who help reinforce learning, address questions, or resolve technical issues (Arachchi et al., 2021; Ayuso & Santiago, 2022; Busse et al., 2022; Chiu et al., 2023; De Felice et al., 2023; Fjellström et al., 2022; Moëll et al., 2015; Rimmer et al., 2022; Silva de Sousa et al., 2018; St. John et al., 2022; Worobey et al., 2018). Some studies highlight a structured sequence of instruction grounded in empirical evidence (Busse et al., 2022; Garcia et al., 2023). Additionally, the modalities of delivery vary, with some programs featuring real-time video calls and interactive sessions between teachers and students (De Felice et al., 2023), while others utilize platforms that offer pre-recorded content alongside messaging systems for communication (Garcia et al., 2023). The duration of these programs also varies

Table 3 Summary of studies characteristics.

Study	Aim	Methodology	Measurements	Instruments	Analysis	Main results
Arachchi et al. (2021)	Analyze how people with intellectual disabilities (ID) perform web searches and design an e-learning tool	Qualitative (iterative participatory approach)	Participants' perspective on Google search, support requirements, computer use and web search skills	Semi-structured interviews and observations	Thematic analysis	Improved web search skills and decreased need for individual support. Effectiveness of teaching and auditory material
Ayuso and Santiago (2022)	Analyze the process of applying dialogic reading in people with intellectual disability level (IDL) in face-to-face and virtual	Mixed methods (multiple case study design)	Average Length of the Statement (LME), percentage of communicative interaction, self-perception of learning	Ad-hoc questionnaire and video recordings	Descriptive analysis, Wilcoxon, and content analysis	Significant difference between all variables for virtual and face-to-face, being lower in the virtual sessions. No significant difference between groups in LME variables. Face-to-face sessions had better results
Bruce et al. (2017)	Analyze whether Drive Smart online training improves hazard perception skills in young drivers with ADHD	Quantitative (randomized (1:1), controlled, parallel group)	Mean time of hazard perception reaction at three moments (at baseline T0, after intervention T1 and after 6 weeks T3)	Hazard Perception Test (HPT)	Descriptive analysis, one-way ANCOVA on HPT change scores, paired-samples t-test	Better scores in G1: magnitude of the change scores at T1 (−0.88); effect on HPT change scores at T1 ($p = 0.02$, $\eta^2 = 0.212$); difference in mean scores at T1 (−1.35). Better scores in G1 in magnitude of the change pre-post ($p < 0.02$; −1.28; $\eta^2 = 20.39$). Improvement of hazard perception skills after online intervention
Busse et al. (2022)	Evaluate a web-based lifestyle, exercise, and activity (LEAP-MS) intervention for people with progressive multiple sclerosis.	Quantitative (non-randomized, single group with pre-test and post-test) and qualitative (perception on process evaluation)	Feasibility, self-efficacy, routine activities, emotional well-being, social participation, fatigue; physical, impact of MS. Intervention Fidelity	Self-efficacy scale (UW-SES-SF); the Oxford Activities and Participation Questionnaire (OxPAQ); health-related quality of life (EQ-5D-5 L); modified form of the Fatigue Impact Scale (MFIS); Multiple Sclerosis Impact Scale (MSIS- 29); Modified Patients' Global Impression of Change (PGIC) and semi-structured interview	Descriptive analysis	Acceptance/adherence: 90.5% received intervention; Recruitment: >50% < 70% (lack of viability); Retention: 76%. Improvements in routine activities and emotional well-being. No changes in social participation. At three months, improvements in the impact of MS and in fatigue, at 6 months the improvements in physical and cognitive fatigue scores were maintained. The LEAP-MS intervention is feasible and associated with improvements in self-management and physical activity skills scores.
Chiu et al. (2023)	Evaluate cognitive abilities, cognitive functioning, and quality of life after virtual reality intervention in older people with cognitive impairment.	Quantitative (randomized controlled trial)	Cognitive skills, cognitive-motor interaction (baseline vs follow training), accuracy, error, and repetition rate (weekly) Intervention Fidelity	Cognitive Assessment Screening Instrument (CASI); Mini-Mental State Examination (MMSE); Clock Drawing Test-Drawing Part, (CDT-D); World Health Organization quality of life scale brief version (WHOQOL-BREF) Taiwan version	Pairwise comparisons (t-tests and chi-square tests), repeated-measures ANOVA, Generalized Estimating Equation (GEE) analyses.	Main effect of treatment group: better scores in VR group in Global cognitive abilities ($p = 0.00$, $\eta^2 = 0.54$); General cognitive functioning ($p = 0.00$, $\eta^2 = 0.42$); Quality of life ($p = 0.00$, $\eta^2 = 0.45$). Medium effect sizes VR intervention improves cognitive function and quality of life

Table 3 (continued)

Study	Aim	Methodology	Measurements	Instruments	Analysis	Main results
Curtiss et al. (2023)	Explore a research-based learning process for creating reliable information about sexuality education on Instagram	Qualitative (community-based participatory research; CBPR)	Experiences and learning acquired.	Interviews	Thematic analysis	Mutual learning on sexual education topics; co-creation (between people with and without disabilities) of accessible, inclusive, and relevant sexuality education content for people with intellectual disabilities through a research-based process. Learning facilitation skills, research, instruction, and using Instagram as an educational tool.
De Felice et al. (2023)	Investigate how people with autism learn online, comparing live learning vs. recorded learning. Compare its impact on people with and without autism.	Quantitative (repeated-measures design (2 (group)×3 (learning condition) ×2 (time))	Difference in learning performance between groups, time, and conditions	Background battery (verbal fluency, non-verbal reasoning and mentalizing), Learning quiz and enjoyment questionnaire (post-intervention and at follow-up)	ANOVA and mixed-linear effect regression model	Main effect of time and learning condition: better scores immediately after the session ($p < 0.001$, $\eta^2 = 0.56$ and $p = 0.03$, $\eta^2 = 0.15$: better scores in Live vs Recorded-alone condition ($p = 0.008$). No interaction effects. Similar results in experiment 2; Regression Model 1: 'Condition' (beta = −0.07, $p = 0.003$); verbal fluency (beta = 0.02, $p = 0.002$) and non-verbal reasoning (beta = 0.01, $p = 0.0003$) were significant predictors of learning performance. Live learning showed better scores immediately after the session, and people with autism performed similarly to those without autism
Fjellström et al. (2022)	Explore the feasibility and effectiveness of a web-based training program for people with intellectual disabilities.	Quantitative (descriptive)	Adherence rate; body composition measurements (fat mass, body mass, waist circumference (WC)), quality of life and PA level (before and after the intervention); PA enjoyment post intervention	Body Composition Analyzer; measuring tape; questionnaire Manchester Short Assessment of Quality of Life (MANSA); International Physical Activity Questionnaire (IPAQ-SF); Questionnaire Physical Activity Enjoyment Scale (PACES)	Descriptive analysis, Paired-samples t-test and Wilcoxon signed-rank test.	High adherence rate: 83%, significantly decreased in fat mass y WC ($p < 0.001$; $p < 0.5$), non-significant changes in quality of life, increased PA level ($p < 0.05$) and enjoyment (3.9 of 5) The application of a web program in adults with ID shows a higher level of physical activity.
Garcia et al. (2023)	Evaluate the feasibility of a remote nutrition education and culinary skills program for young adults with autism spectrum disorder (ASD)	Mixed Method	Feasibility (attendance records, retention rates), Intervention Fidelity	Records, session notes surveys, interview	Descriptive analysis, content analysis and thematic approach	Online nutrition program is viable and well accepted (83% attendance, 7% attrition), offering various communication methods and enhancing knowledge related to nutrition, self-efficacy, and behavioral capacity.

Table 3 (continued)

Study	Aim	Methodology	Measurements	Instruments	Analysis	Main results
Güdül Öz and Yangın (2021)	Evaluate a web-based sexual health education for people with visual impairments	Quantitative (descriptive)	Quality, content, and usability of the website	Personal Information Form; System Usability Scale (SUS), Website Evaluation Form for Individuals with Visual Impairments	Descriptive analysis	High website usability, most useful modules included sexual health and rights (48.86%). Among other suggestions: increase in descriptive images and descriptive videos and greater details in some content, among other.
Mead et al. (2023)	Analyze if institutions offer accommodations to students with disabilities studying online vs. in person	Quantitative (descriptive)	Demographics, disability type and status, frequency of accommodations, and performance	Data register	Descriptive analysis, mixed-effects linear regression, logistic regression	Students in the in-person program were almost 30% more likely to be enrolled in the disability resource center. Students in the online program had a more limited range of accommodations but performed better than those in the in-person program. Students with disabilities in the online program do better than students with disabilities in the in-person program.
Moëll et al. (2015)	Evaluate an online course (Living Smart) for adults with ADHD.	Quantitative (randomized 1:1, controlled, parallel group)	Attention, organization, depression, anxiety, stress, quality of life, general level of functioning, activity, and compliance.	Scales: ASRS subscale measuring Inattention and hyperactivity; Sheehan Disability Scale (SDS); Hospital anxiety and depression scale (HADS); The perceived stress scale (PSS); adapted version of the Clinical Global Impressions Scale-Improvement before and after intervention and structured telephone interviews	T tests, Chi-2 tests, 2 × 2 repeated measures ANOVA.	Reduced average scores on ASRS-Inattention from 28.1 to 22.9 after the intervention, indicating improvements in organization and attention.
Rimmer et al. (2022)	Evaluate the MENTOR program (Mindfulness, Exercise, and Nutrition to optimize Resilience) for people with physical disabilities	Mixed method (multiple case study design)	Effectiveness, physical activity, wellness assessment, participants' perceptions of their experience with the MENTOR program	Enrollment data, Godin Leisure-Time Exercise Questionnaire (GLTEQ), UAB/Lakeshore Wellness Assessment (LWA), interview	Descriptive analysis, paired t-tests, Wilcoxon rank tests, Inductive thematic analysis	Better scores in participant with physically inactive in GLTEQ total activity ($p = 0.005$, $\eta^2 = 0.53$); in exercise behavior ($p = 0.006$, $\eta^2 = 0.39$) in contribution to society/community ($p = 0.013$, $\eta^2 = 0.37$). Better scores in participant with low overall wellness in various measures ($p < 0.05$, $\eta^2_{range} = 0.43$ to 1.07) MENTOR is feasible and potentially effective, showing improvements in physical activity and well-being in physically inactive participants.
Silva de Souza et al. (2018)	Analyze a training system based on a virtual environment (VR) for a blind wheelchair user.	Mixed method (case study)	System performance, participant execution, communication time, signs, physiological data	Systematic observation	Descriptive analysis	Use of VR with EEG signals could improve the quality of life and independence of blind wheelchair users.

Table 3 (continued)

Study	Aim	Methodology	Measurements	Instruments	Analysis	Main results
St. John et al. (2022)	Evaluate a virtual course to improve the mental health and well-being of adults with intellectual disabilities.	Mixed methods: quantitative (non-randomized study of a single group repeated measures) and qualitative (perception participant experience)	Feasible, acceptable, attendance, mental well-being, mental health self-efficacy	Basic demographic data, satisfaction and self-efficacy survey, Warwick Edinburgh Mental Wellbeing Scale (WEMWBS) and interview (before and after intervention)	Descriptive, inferential statistics (repeated measures ANOVA -pre, post and follow-up) and content analysis	Feasible and acceptable course (>88% were satisfied), high attendance (average of sessions, 5 of 6, and average of 14 participants per session), positive changes in mental health self-efficacy ($p < 0.01$), no significant changes in well-being
Worobey et al. (2018)	Determine the effectiveness of a web-based transfer training module in improving transfer technique (independent wheelchair transfers).	Quantitative (randomized control trials)	Transfer technique in three groups (personal training, web training, control).	Demographic questionnaire and Transfer Assessment Instrument (TAI version 3.0) pre, post and follow-up	Descriptive statistics, Kruskal-Wallis Test, Fisher's Exact Test, Friedman Test, Mann-Whitney Tests, and multiple linear regression model	Both in-person and web-based training groups improved post-intervention and at follow-up ($p < 0.01$), with web-based training comparable to in-person training

considerably. Some are conducted in a single session lasting 40–60 min (De Felice et al., 2023; Silva de Souza et al., 2018) whereas others consist of multiple weekly sessions, each lasting 45–60 min, over several weeks (Ayuso & Santiago, 2022; Fjellström et al., 2022).

In general, the findings from multiple studies underscore the benefits of web tools and online learning for people with disabilities, presenting overall positive results. However, when comparing in-person to online learning, the results are mixed. For example, Ayuso and Santiago (2022) observed better outcomes with online formats, whereas Mead et al. (2023) noted that face-to-face settings offer more adaptations beneficial to students with disabilities. Worobey et al. (2018) found that both in-person and web-based training groups showed improvement, with web-based training proving as effective as in-person training. Furthermore, several authors (Curtiss et al., 2023; St. John et al., 2022) emphasize the importance of co-creating learning environments with people with disabilities. They advocate for involving these individuals in the planning and design processes to ensure the environments meet their specific needs and preferences.

Discussion

This review aimed to identify studies focused on training adults with disabilities through electronic means. We adopted the staged selection procedure outlined by Belur et al. (2021) to enhance the accuracy and precision in document selection and minimize observer bias. From this rigorous selection process, we identified 16 studies with diverse characteristics.

In analyzing the gender distribution within these studies, we found no consistent pattern indicating a higher proportion of male or female participants across the entire sample. However, when focusing specifically on the disabled adults within these studies, a higher rate of male participation emerged. This finding aligns with Dechsling et al. (2022), where only 7.4% of participants were women. In our analysis, the gender difference was 11 percentage points, which is somewhat less pronounced than in the Dechsling study. It is important to note that this analysis excluded three of the 16 selected studies due to their lack of gender-specific data (Curtiss et al., 2023; Rimmer et al., 2022) or because they were not focused on a direct intervention program at the time but rather on analyzing accommodations for students with disabilities in online programs over an extended period (Mead et al., 2023). Given the observed gender discrepancies and considering that some reports indicate a higher incidence rate of disabilities among women (Council of the European Union, 2022), future online training initiatives should strive for greater representation of women to ensure equity and inclusiveness.

As noted earlier, with the exception of the study by Mead et al. (2023), most studies we reviewed have small sample sizes, ranging from 1 to 128 participants. This underscores the need for research involving larger sample sizes to enhance the validity and transferability of the findings.

Despite having identified only 16 studies that analyze online training for people with disabilities, our review indicates a rapid growth in research within this field, as 81.3% of the included studies were published after 2021. This surge in research activity is promising and reflects a growing interest in this area of study.

Furthermore, it is noteworthy that half of the studies employed quantitative methodologies, including four controlled trials. Interestingly, 37.5% of the studies utilized mixed methods, an approach that can offer a more comprehensive understanding of the nuances of online training for adults with disabilities. The methodological diversity observed in these studies represents a significant strength, enhancing our understanding of the field's complexities.

Table 4 Summary of program characteristics by study.

Study	Aim	Methodology	Duration
Arachchi et al. (2021)	Learn how to search the web	IT literacy diagnostic sessions, observation of interactions and web search training workshops. It was developed iteratively, incorporating teaching strategies and usability heuristics adapted to people with intellectual disabilities.	3 sessions with an interval of 2 months between them.
Ayuso and Santiago (2022)	Stimulate oral and written communication (communicative interaction, participation, and Average Sentence Length)	Dialogical reading, asking questions, maintaining a dialog, adding more information, and encouraging motivation to tell your opinion	5 sessions, 45 min session/ week
Bruce et al. (2017)	Train in hazard perception driving skills	Incremental Transfer Learning (ITL) model with multiple treatment concepts (insight and awareness training and commentary driving)	1 session, 60 min
Busse et al. (2022)	Learn about aspects of MS and physical activity	Web-based physical activity training with physical therapists using self-management support strategies. Interactive platform (information, selection of activities and a messaging system) The methodology: active learning, guided practice, goal setting, reinforcement, modeling, feedback, and facilitation	6 sessions with a physiotherapist plus access to web-based activity and education packages
Chiu et al. (2023)	Train cognitive skills such as concentration and attention, executive functions of working memory and planning, and psychomotor skills	Sessions are divided into basic, intermediate, and advanced part with different tasks. Immediate feedback provided. The complexity of the intervention progressively increases, and a researcher is present in each session	8 sessions, 60 min
Curtiss et al. (2023)	Create inclusive educational content on aspects of sexuality following an investigative approach and in a collaborative manner	Participatory action research = discussion, analysis, and co-creation of content	No data
De Felice et al. (2023)	Gain knowledge about exotic food, animals, antiques, and rare musical instruments	Learning in three formats: real time (live) video call; video recording of the teacher teaching another student; recording of the teacher explaining a lesson.	1 session, 40 min (video call) and 50 min (answering questionnaires)
Fjellström et al. (2022)	Train physically (strength, endurance, balance, and flexibility exercises)	Participants watched adapted moderate-intensity PA videos (i.e., less instructions and conversations; easier exercises; longer completion periods and inclusion of a stopwatch; rest periods with instructions to drink water)	3 sessions/week, 50 min/ session for 12 weeks
Garcia et al. (2023)	Increasing nutrition knowledge and self-efficacy in young adults with ASD as they transition to independent adult life	Pre-recorded cooking demonstrations. Activities with components of SCT (observational learning, self-efficacy, behavioral capability) and evidence-based practices (modeling, prompting and peer-based)	2 sessions/week, 45 min/ session for 12 weeks
Güdül Öz and Yangın (2021)	Educate about sexual health	Creation of educational web and website content and its evaluation	Six weeks
Mead et al. (2023)	Train future graduates in biology	Online training program with the same structure and characteristics as the face-to-face training program	2014–2019 in the face-to-face modality and 2017–2019 in the online modality
Moëll et al. (2015)	Improve organizational skills and attention	Access to a platform with materials and a messaging system for communication with the coach	6 weeks
Rimmer et al. (2022)	Improve health	Classes were held in group format. Each group met weekly with an assigned health advisor who clarified questions and presented new material	5 sessions/week, 60 min/ session for 8 weeks
Silva de Souza et al. (2018)	Provide efficient interactions with the social environment. Improve locomotion, quality of life and independence	Navigation is carried out in the company of a health professional; first it is by 3D sound orientation and activation by facial signals and then by means of a wheelchair avatar	1 sessions/month, 60 min/ session for 2 months
St. John et al. (2022)	Inform and provide mental health support and education during COVID-19	Online training, design, and co-direction of the sessions by some teachers with intellectual disabilities. Sequencing: presentation, mindfulness, news, presentation of content, discussion, and recapitulation	90 min/session for 6 weeks
Worobey et al. (2018)	Train in transfer through the web	Description and demonstration of transfer skills, discussion of participants' deficits in skills, blocked practice of skills with awareness of performance feedback.	1 session, 60 min

Studies have employed various metrics to assess the effectiveness and viability of online training. Aligning with the evaluation model proposed by Kirkpatrick (2006), the analyzed variables correspond to the first level (reaction), focusing on participants' satisfaction with the training, and the second level (learning), which examines changes in the skills taught. Notably, several studies have delved into participants' perceptions of their learning experiences, which is an essential aspect of the reaction level. For instance, in the study by Güdül Öz and Yangın (2021), participants suggested enhancements to the learning environment, such as the inclusion of more images and videos. This feedback aligns with findings from Contreras-Ortiz et al. (2023), who emphasized the significance of incorporating visual elements like videos and images in the design of educational environments.

Additionally, several of the reviewed studies have focused on implementation fidelity within training programs, an aspect critical to their success. Implementation fidelity refers to the extent to which training is executed as originally designed (Jiménez & Crespo, 2019). This ensures that any shortcomings in the training outcomes are not due to deviations from the planned instruction. Davis Bianco (2010) notes that deviations can significantly diminish the effectiveness of a program. Evaluating implementation fidelity, therefore, not only supports the validity of the training's theoretical and methodological foundations but also substantiates the observed intervention effects. This aspect was notably addressed in the studies by Busse et al. (2022), Chiu et al. (2023), and Garcia et al. (2023) included in our review.

The limited number of studies that employ an evidence-based learning methodology supported by a robust pedagogical framework is noteworthy. According to Murray et al. (2012), practices and interventions for people with disabilities should provide ample learning opportunities, clearly define intended outcomes, offer models, and include guided practices and feedback. Several studies in our review, including those by Busse et al. (2022), Chiu et al. (2023), Garcia et al. (2023), and Worobey et al. (2018), have incorporated these critical elements. Additionally, it is essential for educational platforms and resources to embrace inclusive design principles from the outset, ensuring that accessibility needs are considered during content creation and technology implementation. Contreras-Orticz et al. (2023) emphasize that learning environments should be dynamic and feature a variety of resources along with a robust learning support system. This approach is mirrored in studies like Moël et al. (2023) and Rimmer et al. (2022), which provide structured guidance and support, aligning with best practices for creating effective online learning environments.

Finally, another crucial consideration in creating online learning environments is addressing the specific needs of the intended participants. Studies included in our review, such as those by Arachchi et al. (2021), Curtiss et al. (2023), and St. John et al. (2022), highlight the benefits of this approach.

In general, online programs have been shown to enhance many of the skills being trained, corroborating findings from other research, such as that of Odom et al. (2015). Moreover, some studies, such as Ayuso and Santiago (2022), report improvements using online formats over in-person methods, although other studies present conflicting results. Thus, there is a clear need for further research comparing in-person and online formats to derive more definitive conclusions.

Despite the recent surge in publications related to our research objectives, significant improvements are still needed to enhance access to online training. Digital accessibility remains a paramount challenge, particularly for people with disabilities and older adults who may encounter barriers when engaging with online platforms and digital content not tailored to their specific needs. Compliance with accessibility standards, such as the Web Content Accessibility Guidelines (WCAG), is essential to ensure that online platforms are universally accessible. Additionally, when designing online training programs for adults with disabilities, it is crucial to adopt an interdisciplinary approach. This should involve collaboration among technology experts, pedagogy specialists, and the program recipients themselves. Such collaboration ensures that the programs are responsive to the needs and interests of the users, as highlighted by Curtiss et al. (2023) and St. John et al. (2022). This comprehensive approach not only enhances the effectiveness of the training but also ensures inclusivity and accessibility in the learning process.

As previously discussed, the design of the virtual environment is crucial, yet equally important is the attention to the specific needs of people with disabilities. Supporting these individuals in how to use ICT can significantly enhance their online learning opportunities and success in interaction (Ellis & Goodyear, 2019). This was a key goal of the study by Arachchi et al. (2021), which focused on training individuals in information skills and information literacy to boost their digital competence (Jin et al. 2019).

Moreover, it is essential to recognize that older adults also require targeted support when engaging with ICT. Studies such as those by Briones and Meijering (2021) have highlighted the critical role of social support provided by "technology experts" and the educational resources available through community centers. These supports are vital to ensuring that older individuals can successfully navigate and benefit from technology. Such inclusive approaches are fundamental to making digital education accessible and effective for all learners, regardless of age or disability.

Limitations. While this systematic review provides valuable insights, the scope of information gathered could be broadened through a scoping review. Such a review would allow for the inclusion of additional research and findings from the gray literature, which might offer more comprehensive perspectives on the subject.

Furthermore, future searches should extend beyond the databases currently used, to include specific psychology and education databases such as PsycINFO and ERIC. Expanding the search to these databases could uncover more nuanced and detailed studies relevant to the intersection of online learning, disabilities, and educational outcomes.

Implications for practice. The favorable outcomes observed across all studies in our review, concerning skills such as academic prowess, instrumental abilities, social interaction, personal autonomy, and physical activity, underscore the effectiveness of online and electronic device-based training for adults with disabilities. Nonetheless, there is a clear need to ensure greater representation of women in studies and to expand sample sizes to enhance the robustness and generalizability of the findings.

Furthermore, as suggested by Gorski (2009), there is a critical need to design collaborative digital learning spaces that involve a range of professionals. Such collaboration ensures that the learning environments are not only technologically advanced but also pedagogically sound.

Additionally, assessing implementation fidelity must be prioritized in training programs. This practice is essential to ensure that the training adheres to its intended design, thereby improving the validity and reliability of the results.

Conclusion

Despite the limited number of studies initially identified, the notable increase in research post-2021 reflects a growing interest in online training for adults with disabilities. This trend suggests a

burgeoning concern in this field, though significant gaps remain that require further exploration.

The methodological diversity observed in the studies is viewed as a strength, underscoring the value of mixed-method approaches. These methodologies provide deeper insights into the complexities of online training, enabling a more nuanced understanding.

While the studies generally report positive outcomes in skill enhancement, the variability in results between in-person and online formats underscores the necessity for more targeted and detailed research. This will help to fully comprehend the impacts and effectiveness of different training modalities.

A recurring issue in the analyzed studies is the lack of a clear theoretical foundation and a supportive pedagogical framework. It is crucial for future research and practice to incorporate evidence-based theories and pedagogical strategies. This would ensure that training programs are not only technologically sound but also educationally effective.

Moreover, the studies highlight the importance of training and raising awareness among educators and content developers. Future training initiatives should prioritize interdisciplinary collaboration, involving technology developers, researchers in special educational needs and educational technology, and, importantly, people with disabilities themselves.

The objectives of the programs analyzed are diverse, covering a wide array of skills and knowledge areas. The methodologies employed are specifically tailored to meet these varied objectives and include participatory approaches, learning transfer models, and the use of online platforms. Although basic technology underpins these interventions, the duration of the programs varies significantly, reflecting the complexity and specific goals of each rather than a uniform approach.

Despite the surge in related publications, there remains a pressing need to broaden the scope of online interventions and training for adults with disabilities. This expansion is crucial to fully ascertain the potential and limits of such training. As we advance, it is imperative to maintain a steadfast commitment to ensuring that online education is accessible and advantageous to all, irrespective of individual capabilities or limitations. Such inclusivity is essential for achieving equity in training, thereby enhancing the quality of life and fostering social integration for all individuals.

Data availability

Data sharing does not apply to this article as no datasets were generated or analyzed during the current study. However, the files with the selected articles from the WoS and SCOPUS databases and the link to the RYYAN platform are available from the corresponding author upon reasonable request.

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Author contributions

These authors contributed equally to this work.

Competing interests

The authors declare no competing interests.

Ethical approval

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Additional information

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