Website: http: jebhpme.ssu.ac.ir
EBHPME 2023; 7(4): 315-328
EISSN: 2538-4716

Evidence Based Health Policy, Management & Economics

REVIEW ARTICLE

Evaluating the Effectiveness of Using Virtual Reality Interventions on Children and Adolescents with Autism Spectrum Disorder: A Systematic Review

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A B S T R A C T

Background: Autism spectrum disorder (ASD) is a Psychopathic disorder characterized by abnormal communication and verbal behaviors. ASD is very common in children, affecting about 1 in 160 individuals, and the symptoms of this disorder appear before the age of three, and the main cause is still unknown. The effectiveness of this technology on the abilities required for people with ASD to communicate in a social setting has been the subject of several systematic and comprehensive studies.

Methods: A systematic review by searching in PubMed, EMBASE and CINAHL for publications was conducted from 1 January 2012 to 30 May 2021 involving use of virtual reality interventions on children and adolescents with autism spectrum disorder in which autism, autism spectrum disorder, ASD, virtual reality, VR keywords were utilized. Three reviewers independently investigated search results for inclusion in analysis and resolved disagreements by consensus.

Results: Literature research of databases specifies a total of 808 records. According to the abstract and the full text of the studies, after applying the inclusion and exclusion criteria and eliminating duplicates and screening articles, 15 articles were selected for final review based on the PICO criteria (population, intervention, comparison and results). The studies focused on the five topics of emotion and social interaction, social communication, daily life skills, specific fears and anxieties, physical activity, and attention.

Conclusion: According to reports, the findings rightly claim that the use of virtual reality technologies not only improves the social and communication skills of children with ASD, but also provides them with an engaging and enjoyable experience. Moreover, Parents indicated high satisfaction with VR applications and this technology can contain many benefits in the treatment of ASD.

Keywords: Virtual Reality, Augmented Reality, Autism, Autism Spectrum Disorder

Introduction

An umbrella term used to describe a variety of neurodevelopmental problems is autism spectrum disorder(ASD). These problems are specified through conversation and social interplay problems (1, 2). Individuals with ASD frequently manifest limited, repetitious, and stereotyped signs and symptoms or behavior styles. This ailment initiates in early formative years and lasts for the duration of a person's life (3, 4). ASD is observed in human beings everywhere in the world, irrespective of race, lifestyle or monetary background. Autism is more common in boys than girls, with a male to

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[DOI: 10.18502/jebhpme.v7i4.15482]

female ratio of 4 males and 1 female (5). There is evidence that ASD cases are on the rise. While the severity of signs varies greatly, there are usually problems of social interplay and verbal exchange skills, restrained interests, and repetitious behaviors (6-8). Various studies have demonstrated that technologies such as virtual reality can assist in the management of autism patients (2-4). Virtual reality (VR) has had many definitions in the literature since it was first acknowledged as useful in 1987 (7). In general, the concept of virtual reality (VR) in its simplest definition is the simulation of a world separate from reality that permits the user to enter a space different from his surroundings and engage in the desired experience (8-11). In fact, virtual reality nowadays is described as computer-generated reality. A simulated reality is identified as an artificial world in which the user can place himself with the appropriate technical equipment. The user is given an experience as a result of how this technology operates. Users are interacting with a three-dimensional world rather than the screen in front of them. (12-14).

VR has emerged as a novelty and effective therapeutic approach to various areas of healthcare including diagnosis, surgical training, improving emotional levels in patients and helping to treat mental disorders such as phobias, anxiety problems, obsessive-compulsive issues as well as ASD (15). Considering the two important features of VR, namely the experience of presence and immersion as well as the possibility of repetition and practice in a safe environment, this technology has greatly improved the conversation and social interaction of individuals with ASD by providing the possibility of training in a realistic environment (3, 14, 16). In recent years, research was performed at the efficacy of VR interventions in the field of autism (6, 7, 9, 13, 17). Recent studies indicate that the usage of virtual reality interventions, including computer emulations can assist persons with autism to create low-stress environments and improve their social interactions and communication. Further, these interventions reduce social anxiety by providing a virtual and dynamic environment for frequent practice of social exchanges (18, 19).

The study by Cox et al. (20) exhibited that the utilization of virtual reality driving simulation intervention improved the performance of novice drivers and reduced their panic while driving (20). The Weston study found that virtual reality-based cognitive-behavioral therapies considerably progressed cognition, emotional communication, social skills, and perception of facial expressions in children with ASD (21). Moreover, a study conducted by smith et al. (22) In the field of occupation interview training in individuals with ASD and in which contributors were randomly segregated into two groups of job training intervention through virtual reality and the control group, demonstrated that the persons in the intervention group improved their performance in comparison with the control group (22). Mesa-Gresa et al. (7), after reviewing various articles, reported that VR interventions can enhance many benefits to the remedy of ASD symptoms, but more studies are needed to reveal that VR can efficaciously supplement conventional therapies.

This study aimed to evaluate the effectiveness of virtual reality technologies on children and adolescents with ASD through a systematic review of studies in this field.

Materials and Methods

Search Strategy

The systematic review executed a complete literature investigating PubMed, WoS, and Scopus. Regarding that technology is an crucial part of virtual reality studies, technology has progressed very rapidly in recent years, simplest, latest articles (from 1 January 2012 to 30 May 2021) had been taken into consideration in the systematic review. The search phrases were: (autism OR "autism spectrum disorder" OR ASD) AND ("virtual reality" OR VR). The related studies in the reference section of articles are manually added.

Studies of this type were excluded: Review articles, letter papers, abstracts, editorial manuscripts, and notes. Studies were selected in

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which researchers evaluated the impact of an interventions based on virtual reality technologies on individuals with ASD, and only English-language studies were included.

Selection Criteria

Making the right questions to determine the selection criteria and associated clinical finding in the literature is extremely essential. Therefore, decision was made on the PICO model for this motive due to the fact an excellent query have to encompass four components that perceive the study population (P), Intervention performed (I), Comparison of participants (C), and outcomes of study (O)(7). The following PICO query became set up for the literature choice process:

- P—Persons with ASD
- I—VR-based treatment
- C—(versus) non-VR-based treatment, person's situation before VR-based treatment, without treatment.
- O— principal outcomes obtained

Selection Process

In the PubMed, only studies that targeted on humans have been selected. Second, files belonging to the types of reviews articles, letter papers, study abstracts and editorial manuscripts have been excluded from the records acquired from every database. Third, a selection of the articles was accomplished based on titles and abstracts in every database; then the outcomes of the selection in the three indexes have been evaluated to dispose of duplicates.

Finally, the textual content of every article examined, and the contribution was ultimately decided on if: (1) The study covered individuals with ASD age limitation of 3-19 years (Children and adolescent); (2) the intervention hired treatments based on VR (3) intergroup or baseline evaluations have been performed; and (4) results on participants have been reported. Any discordance was resolved by the choice of the articles based on the authors of this work.

Data Extraction

Eligible articles were reviewed independently by 2 reviewers using a data extraction form that was developed for the purpose of this review and contain data about authors and year of publication, place of survey, objectives of the study, characteristics of the study population, tools used, type of intervention and results were extracted. Any disagreement between reviewers was resolved by team discussion to getting consensus.

Results

A search of selected databases yielded 808 initial studies, 460 records in WoS, 176 records in Scopus and 172 records in PubMed. 63 records from the Wos index and 41 records from the Scopus index were excluded since they were abstracts, notes or reports. Out of a total of 532 records obtained from Wos and Scopus, duplication was reviewed and 296 duplicate articles were reviewed. Abstract of the remaining 236 articles was reviewed and 57 articles were selected to read the full text. With regard to 172 articles extracted from the PubMed index, 29 records were omitted because they failed to perform on humans. Out of the remaining 143 records, the screening of abstracts eliminated 81 articles. After this stage, 62 records remained. After merging the remaining articles from the WoS and Scopus indexes (57 records) and the remaining articles from the PubMed index (62 records), 35 articles were excluded due to duplication. Records that were deleted due to duplication were articles that were exactly the same (for example, the same title, authors and publications, etc.). The flowchart of the selection of articles is shown in Figure 1. Ultimately, the remaining 84 articles were study of their entirety to select articles that have all the selection criteria.

The 15 records that met all the selection criteria are shown in Table 1.

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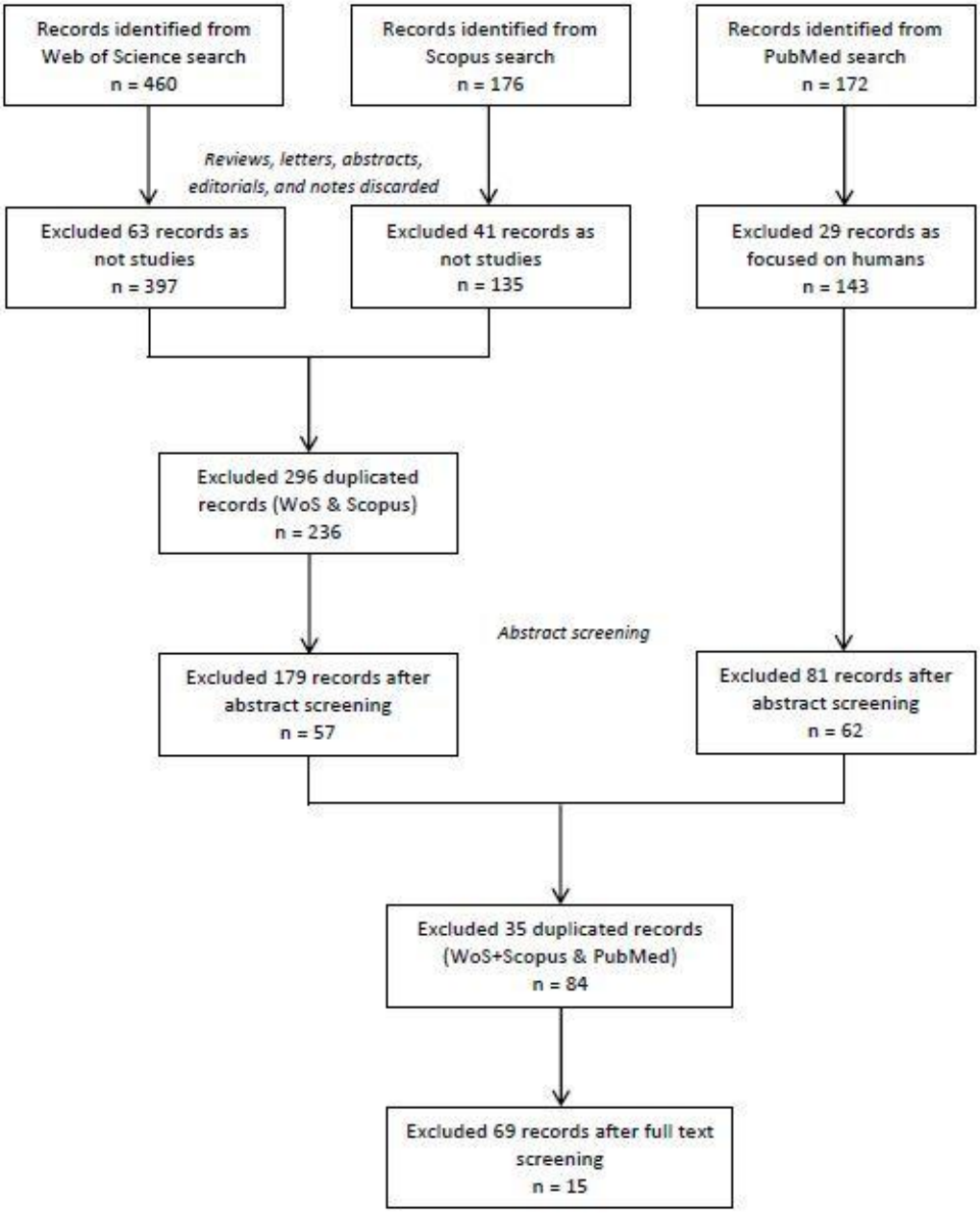

Figure 1. Flowchart of the selection of articles

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Table 1. Final Studies selected for review

Num	Author and Date	Country	Goal	Population			Tools	Intervention	Outcome
				Intervention Group	Control Group	Age Range (years)			
1	Didehbani et al 2016(23)	USA	Feasibility assessing of Virtual Reality Social Cognition Training (VR-SCT)	30	-	7-16	3D simulated training sessions virtual classes avatars feedbacks	Training social cognition through the use of regular everyday social exchanges at the same time as interacting with another a peer and monitored through a trained “coach” clinician who could provide feedback during the interaction rather than education precise computerized interactions.	Improvements of emotion recognition, social attribution, and executive function of analogical reasoning
2	McCleery et al 2020(15)	USA	Usability, feasibility and safety investigating of an immersive VR tool Adolescent's interaction ability improvement with police officers safely and effectively	30	30	12–18	Police Safety Module (PMS tool): computer assisted 3D graphics and an application linked to the iPhone connected to the headset	Side effects monitoring of VR sessions through wireless headset	Verifying safety, feasibility, and usability of immersive VR for verbally fluent kids
3	Kandalaft et al 2013(24)	USA	Training of social cognition by virtual reality intervention to improving social communication, cognition and functioning	8	-	8-16	3D virtual world by Second Life version 2.1 VR technology	Providing dynamic and realistic opportunities by VR-SCT to engaging, practicing and getting feedback from social scenarios by participants.	Post-training significant increases on measures of social cognitive, emotion recognition, real life social and occupational functioning

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4	Dixon et al 2019(3)	USA	Effectiveness assessment of safety skills training by immersive VR environment	3	-	4-10	Oculus Rift and head-mounted device	Teaching of safely crossing the street by training safety skills with VR immersive environment	Promising immersive VR intervention for patients with ASD through training safety skills
5	Cox et al 2017(20)	USA	Training guidelines by virtual reality driving simulation for earning a driver's license	28	23	15.5-19	Virtual reality driving simulation (VRDS), real-time interaction with a driving console and a virtual world	providing a safe environment simulation of driving for individuals by virtual reality intervention to taking a driving license	Significantly improving in driving and performance of executive function over routine training by VRDST
6	Miller et al 2020(25)	USA	Reporting functional communication activity of air travel by VR implementation	5	-	4-8	iPhone X, Google Cardboard device and VR-based air travel training (VR-ATT) module	Training of air travel by combining traditional functional communication based on experience of air travel with VR-ATT module	Improving skills of air travel from pre to post intervention in all children
7	De Luca et al 2019(4)	Italy	Stimulation of behavioral and cognitive abilities by Applying a training VR tool (BTS-Nirvana) on an affected ASD boy	1	-	16	Movement-based system, interactive VR scenarios and audio-video stimuli	Providing a one-month cognitive behavioral therapy and a combination method of the BTS-Nirvana System) and CBT	Improvement in skills of spatial cognition and attention processes with combined approach, with ideomotor stereotypes significantly reduction
8	Fitzgerald et al 2018(26)	Australia	Video modeling (VM) effectiveness in comparing of virtual reality (VR) for with ASD patients teaching	2	-	12 & 14	GoPro 4 HERO Black, custom 194-degree fisheye lenses, Adobe software and, Oculus Rift	Completing projects of paper folding via espousing task modeling of VM or VR with designing alternating treatments	Reaching one participant for the intermediate project to mastery criterion with both VR and VM on the

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							Consumer Version 1 (CV1) and head mounted display (HMD)		5th trial. Achieving the other participant by the 6th trial of VM to mastery, but failing to maste attention in VR. Suggestion of more efficacy of VM in comparing VR in learning facilitation by enjoying report of Both participants.
9	Meindl et al 2019(5)	USA	Developing a VR-based exposure therapy for one ASD adolescents with extreme needle phobia history	1	-	16	An Apple Pencil stylus, a television, Tzumi Dream Vision VR Headset, an iPhone 6s to, and an Insta360 One VR camera	Treatment affects evaluation using a changing criterion design with two baselines and a final generalization phase about participant's phobic responses to blood draws.	Combining virtual reality with exposure therapy may produce an effective intervention for medical phobias.
10	Lahiri et al 2013(27)	USA	Intelligently facilitating engagement associated with advancing abilities of social communication in tasks through developing novel VR-based interactive system with Gaze-sensitive adaptive response technology	8	-	13-18	VR-based module of social communication task, a real-time monitoring eye-gaze module, and an individualized adaptive response module	Social conditions improvement with context-associated backgrounds, and avatars whose look resemble in age and people of the participants' friends without looking to obtain actual similarities.	Demonstrating the capability of VR-based social communication obligations to promote progressed social mission performance together with socially-suitable mechanisms

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Num	Author and Date	Country	Goal	Population			Tools	Intervention	Outcome
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11	Smith et al 2015(28)	USA	VR-JIT efficacy evaluating of high-functioning ASD adolescent (range of 15–19) who were actively in search of employment	15	11	15-19	Virtual Reality Job Interview Training (VR-JIT) application	job interview simulation with a virtual human assets' consultant and generates interview questions	VR-JIT can be a useful intervention for with high-functioning ASD
12	Zhao et al 2018(29)	USA	Developing a collaborative virtual environment (CVE) for children with ASD to promote social interaction	12	12	12-16	Leap Motion controller (gesture-based interactive instrument), Puzzle Games, Collection Games and Delivery Games	Providing collaborative games for children with ASD and their peers, to analyze performance of the participants in a naturalistic social interaction platform through increasing communication and cooperative opportunities	Participants enjoy the collaborative games, confirm the importance of relationship and cooperation with partners for success and having been influenced by partner
13	Maskey et al 2014(30)	England	Developing and evaluating a cognitive behavior therapy method in a virtual reality environment	9	-	7-13	Blue Room video clips virtual reality environment	Guiding contributors by a psychologist to perform behavioral and cognitive techniques in a virtual reality environment to the phobia/fear stimulus exposure	Making phobia situation tackling ability in eight of nine children. Completely phobia overcoming by Four of the participants.
14	Vanessa Yuan and Shing Ip 2018(9)	Hong Kong	Examining of VR training program efficacy for social and emotional skills of ASD children	65	62	11-15	Four-side Cave Automatic Virtual Environment (CAVE) and virtual reality scenarios with	Separate entry and movement of children to CVE with the guidance of the instructor	obtaining higher score on social interaction and regulating and expressing emotions than before training

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Num	Author and Date	Country	Goal	Population			Tools	Intervention	Outcome
				Intervention Group	Control Group	Age Range (years)			
							objects and avatars		
15	Wang and Reid 2013(1)	Canada	Assessment of a novel VR-CR intervention efficacy with the purpose of improving on cognitive flexibility, abstraction and contextual processing of objects in autism children	4	-	6-8	Virtual reality tests using an Acer TravelMate 8204 laptop computer and Motion-capture technology using a tracking webcam (Logitech QuickCam Pro 9000)	Training how to see objects in the text through strengthening the pivotal information	Statistical improvements in cognitive flexibility and overall contextual processing ability by participants

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A total of 359 subjects participated in these studies, 221 individuals in the group of intervention and 138 participants in the group of control. In total, only 5 studies compared the group of intervention with the group of control, and in 10 other articles, the effect of the intervention was investigated only on the intervention group. The sex distribution for ASD participants in the intervention group was as follows: 73.45% of the participants were boys and 26.55% of the participants were girls. With regard to the effectiveness of the studies, all of them reported that VR-based therapies improved at least one of their goals. However, only 3 studies reported that these improvements were significant statistically. Most of the studies were conducted in the United States, with 10 of the 15 studies belonging to the United States, and each of the following countries had one study: Italy, Australia, the United Kingdom, Hong Kong, and Canada.

In most studies, medical attention focused on social and/or emotional skills (40%), as well as emotion recognition, social interaction, and collaborative tasks. A total of three studies (20%) developed children's communication skills. Two studies (13.33%) try to improve daily living skills, especially driving and crossing the street. Two studies (13.33%) were designed to reduce a specific phobia or fear. One study (6.66%) was targeted to improve physical activities, and one study (6.66%) was focused on attention. Figure 2 displays the percentage of studies that concentrated on each clinical target.

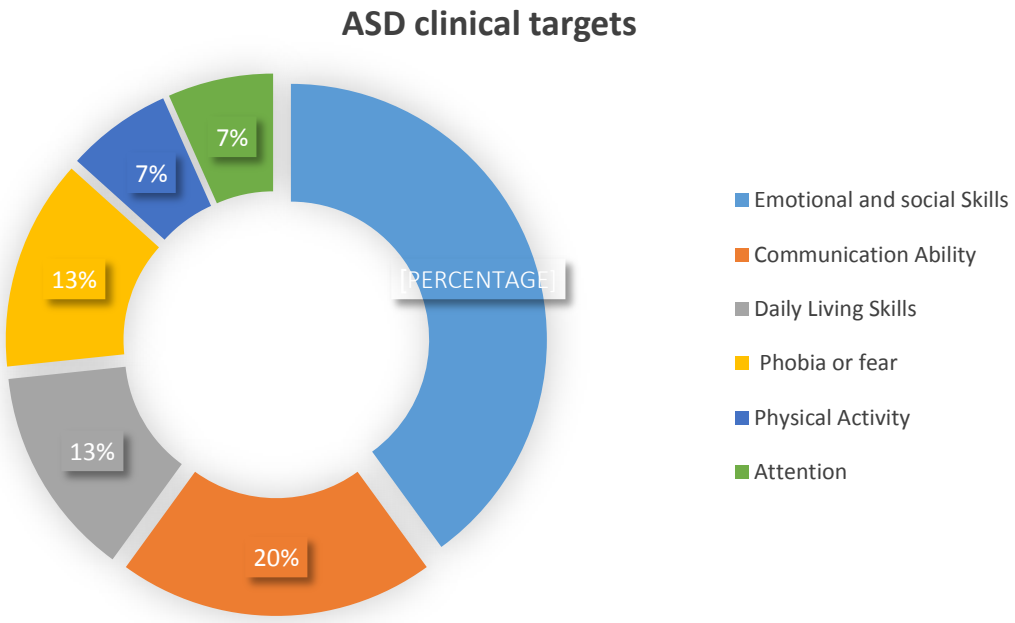

Figure 2. Categories of Virtual Reality Interventions in ASD

Emotional and social Skills

A total of six studies concentrated on social skills intervention in ASD children. The age range of the samples was 4 to 19 years and the mean age of the participants was 10.5 years. Seventy nine boys and 14 girls participated in the reviewed articles. Virtual reality environments and scenarios, and in some cases the use of avatars, were the fundamental technologies applied in the interventions.

Communication Ability

This category contained three articles. In two of these articles, a detailed description of the instances was provided and it was noted that the age range of the participants was between 6 and 18 years with an average age of 11.75 years. However, only the sex of the participants with 9 boys was specified in another article. The used technologies in these interventions included AR

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and VR elements and CVE games.

Daily Living Skills

In this category, interventions were performed based on training in tasks and skills pertinent to daily life, such as crossing the street or driving. There were two studies in this group in which the age range of participants was between 8 and 19 years and the mean age was 15.5 years. The samples in these studies consisted of 43 boys and 11 girls. The utilized technologies in these studies contained VR driving modules and VR scenarios.

Phobia or fear

Technologies for psychological interventions of fear in children with autism were included in two studies in this category. The participants in this study were all boys and ranged in age from 7 to 16 years with a mean age of 10 years. In this intervention, the virtual reality environment and the Blue Room with unique sensors were used.

Physical Activity

This category included an article that sought to boost motivation in physical activity. The age range of the samples was 4 to 8 years (with a mean age of 6.5 years). In these interventions, stereoscopic screens were applied to immerse individuals as VR technology.

Attention

There was only one article in this category that was selected according to Attention Training. Only a sixteen-year-old person participated in this study. The employed technologies in these interventions included virtual reality scenarios and a mobile object recognition system.

Discussion

This systematic study aimed to review and report the effectiveness of VR interventions in the treatment processes of children and adolescents with ASD. Fifteen published research papers between 2012 and 2021 in the WoS, Scopus and PubMed databases were analyzed for this systematic review. The age range of study participants was 4-19 years and their mean age was 10.5.

According to reports, the findings rightly claim that the use of virtual reality technologies not only improves the social and communication skills of children with ASD, but also provides them with an engaging and enjoyable experience. Additionally, parents revealed high satisfaction with VR applications (25, 26, 29, 31). Most studies have concentrated on promoting emotional communication, social interaction, and daily activities such as driving and shopping due to the opportunities that VR provides. The crucial disadvantage in children with ASD is social skills, and most studies in this field have performed interventions (7, 32). Furthermore, interventions in the field of daily life skills, physical activity, and fears have been frequently considered in studies; which improved participants' performance by creating repetitive, stress-free interactive and participatory virtual environments (33, 34). Articles that offered emotional interventions basically used avatars and games to learn and regulate emotional reactions. Different studies have applied various tools to implement virtual reality interventions. Some studies have utilized mobile devices, which is regarded as an advantage since it can be used anywhere (7, 17, 30).

The results of the studies indicated the positive effects of VR intervention on ASD patients. However, it is momentous to note that the outcomes were obtained from small instances and in most papers, no accurate comparison was made between the intervention and control groups, and also another issue that could overshadow the results. One of the main criticisms in this regard is the absence of physisions and therapists from studies intended to educate and train autistic populations. (16, 35). Lack of long-term studies to determine whether these technologies actually assist ASD patients in enhancing their social and communication skills is another limitation of the results. (31).

Conclusion

The results of the study manifest that there is not enough evidence to express that VR is significantly

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effective in ASD patients. However, the promising advantages of VR can motivate the community to use VR-based therapies and the implementation of studies with appropriate population design and homogenized samples with a large number, with the participation of therapists and families of children with ASD and for a long time, is recommended in the future; In order to apply its numerous possible positive results to improve the performance of these patients.

Acknowledgements

The authors would like to thank the Health Information Technology Department of Tabriz University of Medical Sciences.

Authors' Contributions

Alizadeh-dizaj GH, Damanabi SH, and Raoofi S P designed research; Alizadeh-dizaj GH and Khoshsirat SH conducted research; Alizadeh-dizaj GH, Damanabi SH, Raoofi S and Khoshsirat SH analyzed data; and Alizadeh-dizaj GH and Damanabi SH wrote the paper. Damanabi SH had primary responsibility for final content. All authors read and approved the final manuscript.

Ethical Considerations

Reporting of all information without bias and participation of all research people in the preparation of the article and data analysis were the ethical issues observed in this research.

Ethical Approval

Non applicable**.**

Conflict of Interests

The authors declared no conflict of interests.

Funding

Non applicable**.**

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