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A SYSTEMATIC REVIEW ON THE EFFECTIVENESS OF COMPUTER GAMES APPLICATION IN PATIENT REHABILITATION

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ABSTRACT

Background: In the earlier days of its existence, electronic games were made in science laboratories as part of experimental research. With the advancement of technology and the availability of resources, electronic games developed across multiple devices. Computer games are one variation resulting from the evolution of electronic games. Computer games, which initially focus on their application as one of the leisure and fun activities, have also evolved. Nowadays, computer games are also being used in multiple sectors for various purposes, such as learning tools, training, monitoring, and assessment. This systematic review is aimed at evaluating the effectiveness of the application of computer games in rehabilitation.

Materials and Methods: The researchers reviewed EBSCOHOST, PubMed, and ScienceDirect databases for articles published from January 2015 to December 2020. We searched for published randomised controlled trial intervention studies on the application of computer games for healthcare in the domain of rehabilitation. We looked for the variety of the computer games application in rehabilitation and their effectiveness.

Result: Three hundred articles were identified, of which only five studies fulfilled the eligibility criteria and were included in the review. The reviewed studies involved rehabilitation patient with stroke, cerebral palsy (CP) and attention deficit hyperactive disorder (ADHD). Computer games or video games are being applied as an intervention in all studies, either as a stand-alone component or complementary. All five articles reported that computer games application is an effective tool in rehabilitation.

Conclusion: Overall, the application of computer games in rehabilitation programs has favourable effects on the patient's outcome. However, further research is needed to assess the cost-effectiveness, superiority, and feasibility of such an intervention compared to the traditional approach before its application can be widely recommended.

Keywords: computer games, video games, gaming, healthcare, rehabilitation, self-care, monitoring, training, physical activities

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1.0 Introduction

Starting from experimental research in laboratories, electronic games have evolved in various forms of devices from computer simulation, arcade games, video games consoles, home computers, and mobile phones. Previously, computer games' development focused on fun and leisure. Nowadays, computer games are also used in sectors such as sports, military, and healthcare for learning tools, training, monitoring, etc. The advancement in technology such as Kinect, a device developed by Microsoft that allows physical movement to be detected by the game console and reflected in the game portrait on the screen, open up the opportunity of integrating computer games with more serious purposes such as in patients' rehabilitation in healthcare (Miclaus et al., 2020).

Britannica Academic, an online up-to-date academic resource database, defines games as "a universal form of recreation generally including any activity engaged in for diversion or amusement and often establishing a situation that involves a contest or rivalry" (Britannica Academic, 2020). Jouni Smed (2013) mentioned that games involve three components: participation of players by their own will for enjoyment, diversion, or amusement, a set of rules which define limits of gameplay, and goals that set the competition or rivalry among the players. A computer game is a subset of a game that runs on a computer program. Traditionally, the program can be divided into the game process's coordination, an illustration of the situation, and participation as players (Jouni Smed, 2013). Games usually integrate with an electronic display in this modern era, which acts as a visual illustration portraying the interaction between players and machines. Other players could also exist, mediated by a meaningful fictional context, and sustained by an emotional attachment between the player and the outcomes of their actions within this mythical context (Arjoranta, 2019).

The worldwide billion-dollar gaming industry, including Malaysia, has grown from being played on personal computers (PC) and mobiles to consoles and virtual reality (VR). In 2018, the gaming industry alone contributed US$100 million to Malaysia's revenue with an annual growth rate of 10.9 percent and would expect to grow to US$168 by 2023 (MIDA, 2020). Along with advancements of electronic games for mainly entertainment purposes, it also paved the way for its use in education, including the healthcare sector through Interactive Health Games (IHG) and serious interactive games (Aziz, 2018). For instance, IHG is more feasible in improving cognitive function, physical and social activity, knowledge sharing for health education and risk-prevention, behavioural intervention, and disease self-management (Aziz, 2018; Ferdig et al., 2009). Numerous studies have also identified the impact of serious games on improving patient's motion, self-management, operationalising, and many more (Hickman Jr et al., 2015; Jackson et al., 2020; Oña et al., 2018). Computer games could be referred to as games on a personal computer. They are often described as video games, electronic games, or digital entertainment (Tavinor, 2008). The term computer games and video games will be used interchangeably will be the term used, as it has the virtue of referring to the aspect of technology used for the application of computer games for healthcare.

1.1 Application of computer games in healthcare

Games development was for fun and leisure, especially for children and young adults. However, their benefits rely on the type of games they are engaged in, where time spent on such gadgets playing games may negatively affect their aggression and school performance, especially with

violent content. In contrast, educational content is beneficial (Hastings et al., 2009). With the expansion of technology, the use of video games has been broadened to various categories, including its use in school children for educational purposes and in military training (Hastings et al., 2009; Orvis et al., 2010). Recent studies have shown that video games play a positive role in healthcare for rehabilitation therapies, self-care monitoring, training, or physical activity.

Games are used comprehensively for patients of both flights of ages in children and adults for health. A randomised control trial (RCT) study on adults with chronic disorders such as cardiovascular diseases with a game-based mobile app has been conducted to prevent further complications through decreasing risk factors (Gallagher et al., 2019). The study aimed to improve physical activity in terms of the metabolic equivalent of task units/week (MET-min/week) through the *MyHeartMate* game app, which requires the player to decide or purchase items for their avatar's health. The real-world secondary prevention tasks would reflect and change the patient's lifestyle (Gallagher et al., 2019). Meanwhile, an interventional study by Bul et al. (2018) found that children who had serious games intervention improved significantly on time management and responsibility outcomes compared to children with ADHD who received the usual treatment. The 20-week open-label RCT used an online computer game called "Plan-It-Commander" designed by healthcare professionals and game experts to improve functional outcomes in the children's daily lives versus the treatment as usual (B*ul et al., 2018)*.

1.2 Video Games and Rehabilitation

Effects of video games on intervention among CP children significantly improve the upper motor functions in an RCT study by Sajan et al. (2017) using an interactive video game, boxing, and tennis on the Nintendo Wii game console. Outcomes showed improvement in balance and postural control, upper limb functions, and functional ambulation (Sajan et al., 2017). In a study for a home-based post-stroke rehabilitation study using two different training modes, coaching (by a Virtual Coach) and game (movement of the user mapped in real-time) according to the scenario displayed on the screen; increased movement quality with increased enjoyment was concluded (Cameirão et al., 2016).

A significant barrier to complete rehabilitation is the patient's nonadherence. According to Lohse et al. (2013), research suggests that cognitive and motor skill learning could benefit from video games as behavioural, physiological, and motivational effects further help therapists to assist patients. Video game delivery of the Constraint-Induced Movement Therapy (CI Therapy) for upper extremity hemiparesis rehabilitation by delivering engaging high-repetition practice offers promising results compared to the traditional clinic-based approach (Gauthier et al., 2017). This type of training is associated with increased striatal dopamine, which further promotes learning and better precision in the therapy (Lohse et al., 2013). With the expanding role of video games in healthcare, this study aims to review the effectiveness of the application of computer/video games in rehabilitation.

2.0 Materials and Methods

This review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines based on the Cochrane Collaboration approach (Higgins, 2011; Liberati et al., 2009).

2.1 Eligibility criteria

We selected interventional studies that looked into the effectiveness of the application of computer games for healthcare in rehabilitation. We chose an interventional study with randomised control trial design and full-text available. We exclude non-English language studies, qualitative studies, systematic and literature reviews, protocols, and studies that involve mobile games and applications.

2.2 Data sources and search strategy

We used EBSCOHOST, PubMed, and ScienceDirect to search for relevant articles within the duration of 5 years, from January 2015 to December 2020. We combined the keywords for computer games, video games, gaming, healthcare, rehabilitation as the following: Computer games for healthcare OR video games for healthcare OR gaming for healthcare AND rehabilitation.

2.3 Data extraction and data analysis.

The researchers came out with a table of a logical framework for the documentation of the extracted articles. The information included in the table is study background (year, title, types of study, target group), name and types of computer games, intervention, and effectiveness outcome. All articles being extracted independently by the researchers and compiled for comparison and duplication counter-checked. Any discrepancies on the eligibility criteria of the articles were discussed and resolved through discussion.

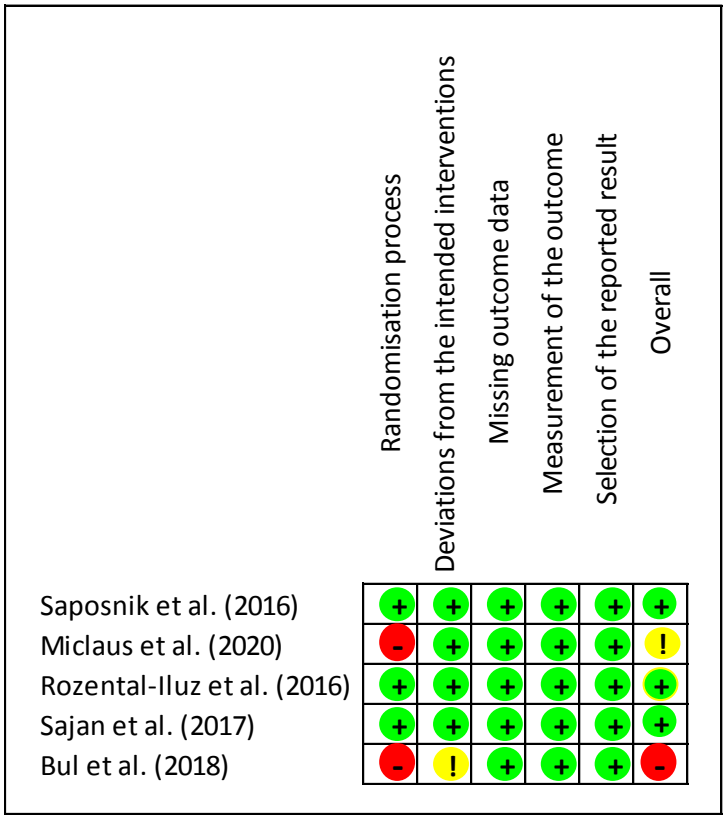
We analyse the articles, looking into the frequency of the target groups, names, and types of the computer games' applications that appeared in the search. We take studies that measure computer games' effectiveness as an intervention in rehabilitation compared to the conventional rehabilitation approach; the supporting data on rehabilitation effectiveness determined by the verified assessment tools used in the study.

2.4 Risk of bias assessment

The researchers assess the risk of possible bias based on five criteria as presented in the S1 Table and Fig 1(a) to 1(b). In randomisation process, the study by Miclaus et al. (2020) and Bul et al. (2018) being assessed as high risk as the allocation sequence was not concealed before participants' enrolment and assignment to interventions. The randomisation process for risk of bias in other studies was assessed to be of low risk. Upon assessment of deviations from intended intervention, the study by Bul et al. (2018) was evaluated to be of some concerns as the participants, the carers, and people delivering the intervention were probably aware of the intervention. The assessment of deviations from the intended intervention for other studies was

assessed to be of low risk. All studies were considered to be of low risk on missing outcome data, measurement of the outcome, and selection of the report result. For overall bias, one study being assessed of some concerns (Miclaus et al., 2020) and one study being assessed as high risk (Bul et al., 2018). Three other studies were evaluated to be of low risk for overall bias (Rozental-Iluz et al., 2016; Sajan et al., 2017; Saposnik et al., 2016).

(a)



(b)

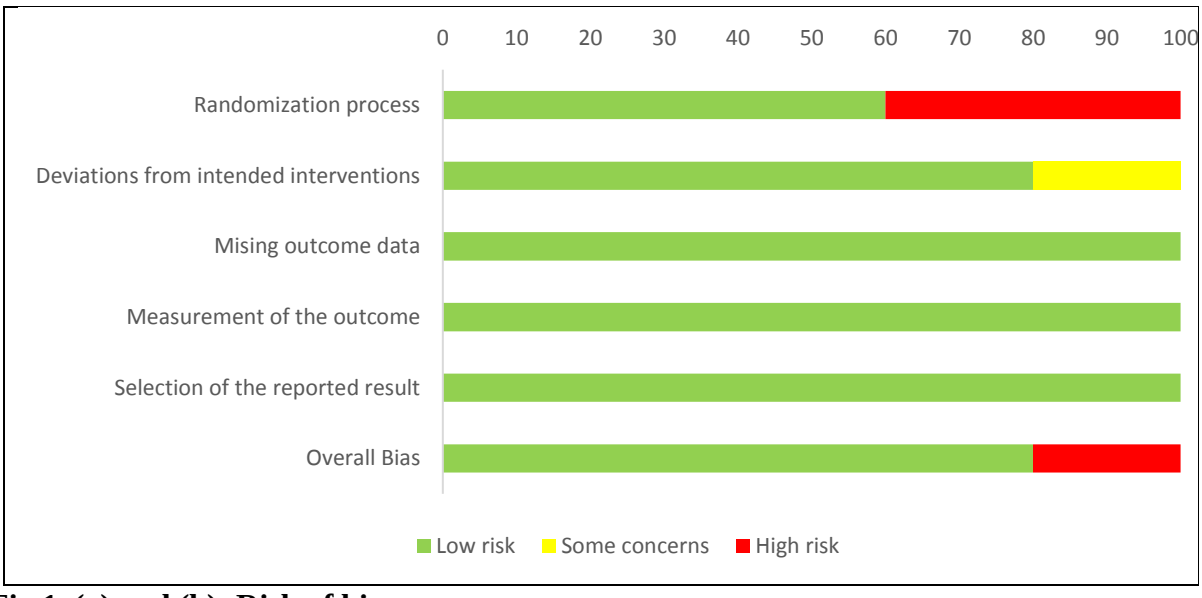


Fig 1. (a) and (b): Risk of bias assessment.

3.0 Results

Table 1. Result Hits Table for Search Terms and Literature Database (2015-2020)

Search terms	Hits in EBSCO HOST	Hits in PUBMED	Hits in SCIENCE DIRECT	Combined Hits	Duplication	Final
Computer Games for Healthcare OR Video Games for Healthcare OR Gaming for Healthcare AND Rehabilitation	175	107	18	300	38	262

We identified 300 articles with full texts related to our research interest from our search through defined electronic databases. The results from all platforms were combined. Thirty-eight articles were removed after duplication was identified, resulting in 262 articles for screening. We excluded 228 articles after titles and abstracts evaluation for irrelevant study interest (application of computer games in training, monitoring, self-help, physical activity, etc.). Thirty-four articles were then screened further. Another 29 articles were excluded for out of topic interest (e.g., measuring tool's effectiveness in rehabilitation, training), irrelevant study designs (descriptive study design, protocol study, feasibility study, systematic and literature review), mode of application (mobile games and application), and equal application of interventions (computer games compared with computer games). Finally, five studies were included in this review.

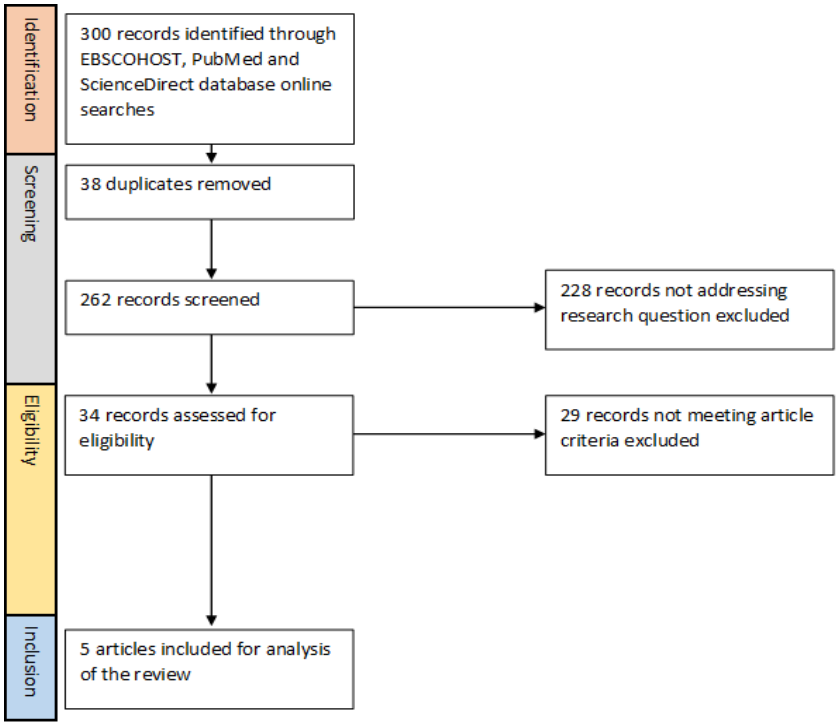


Fig. 2. PRISMA 2009 Flow Diagram

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Table 2. Characteristics of computer games used in studies

Study (Citation	Title	Study Design	Target Group	Name of CG	Type of CG	Intervention
Saposnik et al. (2016)	Efficacy and safety of non-immersive virtual reality exercising in stroke rehabilitation (EVREST): a randomized, multi-center, single-blind, controlled trial	Randomized controlled, single-blind, parallel group	Adults (aged 18–85 years) first-ever ischaemic stroke and a motor deficit of the upper extremity	VRWii	Kinect Virtual Reality	Received Virtual Reality Wii therapy (10 session 60 minutes each for 2 weeks) as add-on therapy to conventional rehabilitation.
Rozental-Iluz et al. (2016)	Improving executive function deficits by playing interactive video games: secondary analysis of a randomized controlled trial for individuals with chronic stroke	Randomized controlled trial	Adults aged 19 years or older who had a stroke at least six months before the study could walk 10-meters with or without assistance, with executive dysfunction deficit.	Xbox Kinect, Nintendo Wii Fit, Sony PlayStation 2, Eye Toy, Sony PlayStation 3, MOVE virtual reality system developed specifically for rehabilitation (SeeMe System, Brontes Processing, Kfar Saba, Israel).	Kinect Virtual reality Video games	Received video games rehabilitation intervention included playing in pairs on two different consoles each session for two 1-hour sessions per week for three months.
Sajan et al. (2017)	Wii-based interactive video games as a supplement to conventional therapy for rehabilitation of children with cerebral palsy: A pilot, randomized controlled trial	Randomized controlled trial (Parallel group randomized design)	Children with CP aged 5-20 years with sufficient balance to play Wii games in the sitting or standing position, adequate functional hand skills to hold the Wii remote, and cognitive skills to follow directions to play the games were included.	Wii	Kinect Virtual reality	Received rehabilitation intervention included playing Wii games for 18 sessions of 45 minutes each, over a period of 3 weeks under the supervision of an occupational therapist.
Bul et al. (2018)	A serious game for children with Attention Deficit Hyperactivity Disorder: who benefits the most?	Randomized controlled trial	Clinically diagnosed with ADHD, stable on pharmacological and/or psychological ADHD treatment for eight weeks prior to baseline.	Plan-it-commander.	Online computer games	Received a serious game intervention besides treatment as usual for the first ten weeks and then received treatment as usual for the next ten weeks.
Miclaus et al. (2020)	Non-Immersive Virtual Reality for Post-Stroke Upper Extremity Rehabilitation: A Small Cohort Randomized Trial	Randomized controlled trial	Stroke survivors after the acute phase, at least six weeks post-stroke; mild impairment, minor cognitive impairment Stroke survivors within no more than four years after a stroke, at least 30-degree flexion and scapulohumeral abduction against gravity, and at least 30-degree elbow flexion against gravity.	MIRA (a software telerehabilitation tool).	Kinect Virtual Reality	Received 20 to 40 minutes of VR therapy (set according to the patient's capacity) associated with dexterity exercises (occupational therapy exercises) for ten working days for two weeks.

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3.1 Characteristics of the included studies.

A final of five articles have been included in the review. Three studies were conducted among stroke patients (Miclaus et al., 2020; Rozental-Iluz et al., 2016; Saposnik et al., 2016), while one study was found for each in cerebral palsy (Sajan et al., 2017) and ADHD (Bul et al., 2018). Three of the studies use Kinect based games as their mode of intervention for the rehabilitation program (Miclaus et al., 2020; Sajan et al., 2017; Saposnik et al., 2016), one study used a combination of Kinect based games and video games (Rozental-Iluz et al., 2016) and one study was using online computer games (Bul et al., 2018). One study was involved in the rehabilitation of the patients' executive function (Rozental-Iluz et al., 2016) and one study on the rehabilitation of cognitive aspect (Bul et al., 2018) and the remaining focusing on the mechanical function of the patients in balance and upper limb and motor functions rehabilitation (Miclaus et al., 2020; Sajan et al., 2017; Saposnik et al., 2016).

3.2 Characteristics of computer games

Kinect is a device developed by Microsoft that can sense movement by the human body installed with video games during gameplay (Miclaus et al., 2020). As mentioned above, Kinect technology was used in four out of five studies researched, involved patients with impaired motor functions in upper or lower limbs, in post-stroke patients, or patients with CP. Serious game intervention is used in children with ADHD.

Patients with restricted movement disabilities recruited to participate in the studies were those who had relatively mild-to-moderate conditions, adequate motor abilities to perform arm or hand movements, and walking for a short distance. Participants should also have cognitive functions to follow instructions given by the instructors. Children involved should be stable, having intervened pharmacologically or psychologically, or both, two months prior. Preceding intervention, consent is taking from participants and parents. All studies were ethically approved and registered by local clinical trial committees.

Randomization in a 1:1 ratio was carried out, with half of the participants receiving routine therapy while the other half received computer or video games sessions specified for the patient. Both control and game-therapy assigned groups received intervention for a period of between 2 to 10 weeks. For instance, parents randomly received an email on which group they were assigned to in the serious game intervention "Plan-it Commander" in the ADHD clinical trial. Participants were asked to play the programmed game for not over 65 minutes in one 24-hour period to prevent excessive use of the game, approximately three times per week. Assessment time points are specified to measure with baseline data and evaluate the outcome through a questionnaire for parents, teachers, and children involved.

Likewise, post-stroke patients or children with CP in the trials were given game therapy involving the upper extremities and other sets of exergames in addition to the standard conventional method. Studies used different assessment methods to measure pre- and post-intervention methods such as time doing specific tasks on WMFT (Saposnik et al., 2016), the Trail-Making Test B (Rozental-Iluz et al., 2016), and other measures that will be highlighted below.

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Table 3. Characteristics of the intervention and assessment tool

Study (Citation)	Title	Intervention	Control	Assessment Tools	Outcome Intervention	Outcome Control
Saposnik et al. (2016)	Efficacy and safety of non-immersive virtual reality exercising in stroke rehabilitation (EVREST): a randomized, multi-center, single-blind, controlled trial	Received Virtual Reality Wii therapy (10 sessions 60 minutes each for two weeks) as add-on therapy to conventional rehabilitation	Received recreational activity (10 sessions 60 minutes each for two weeks) as add-on therapy to conventional rehabilitation	Wolf Motor Function Test (WMFT)	Improved WMFT performance time relative to baseline at the end of the 2-week intervention. Multivariable analysis adjusted for baseline WMFT score, age, sex, baseline Chedoke-McMaster, and stroke severity revealed no significant difference between groups in the primary outcome	Improved WMFT performance time relative to baseline at the end of 2-week intervention. Multivariable analysis adjusted for baseline WMFT score, age, sex, baseline Chedoke-McMaster, and stroke severity revealed no significant difference between groups in the primary outcome
Rozental-Iluz et al. (2016)	Improving executive function deficits by playing interactive video games: secondary analysis of a randomized controlled trial for individuals with chronic stroke	Received video games rehabilitation intervention included playing in pairs on two consoles each session for two 1-hour sessions per week for three months.	Received traditional intervention included exercises in sitting and standing, walking, and performing functional tasks in pairs or triads that encouraged the entire body's movement (transferring objects, folding laundry, throwing-catching balls). for two 1-hour sessions per week for three months.	The Trail Making Test (Parts A and B) The Bill Paying Task from the Executive Function Performance Test (EFPT) Executive Function Route-Finding Task (EFRT)	Scores for the Bill Paying Task (EFPT) decreased by 27.5%. * Small effect size (pre to post, and pre to follow-up) was found for Paying Bills Task (EFPT), showing the need for fewer cues to complete the task.	Scores for the Bill Paying Task (EFPT) decreased by 36.6%.

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Sajan et al. (2017)	Wii-based interactive video games as a supplement to conventional therapy for rehabilitation of children with cerebral palsy: A pilot, randomized controlled trial	Received rehabilitation intervention included playing Wii games for a total of 18 sessions of 45 minutes each, over three weeks under the supervision of an occupational therapist as a supplement to the conventional therapy.	Received conventional therapy alone, which consisted of a goal-directed, comprehensive rehabilitation program.	Posture control: Static posturography The paediatric Berg's balance scale. Upper limb functions: Box and Block Test Quality of Upper Extremity Skills Test (QUEST) Visual-perceptual skills: Test for Visual-Perceptual Skills (TVPS) – third edition. Functional ambulation by walking distance and speed.	For all the outcome measures assessed, the post-test minus pre-test scores in the intervention group were not statistically different from those in the control group. *Upper limb functions, assessed by grasp domain of QUEST, showed significant improvement in the intervention group but not in the control group.	For all the outcome measures assessed, the post-test minus pre-test scores in the intervention group were not statistically different from those in the control group.
Bul et al. (2018)	A serious game for children with Attention Deficit Hyperactivity Disorder: Who benefits the most?	Received a serious game intervention in addition to treatment as usual for the first ten weeks and then received treatment as usual for the next ten weeks.	Received treatment as usual (medication in 92% of the cases) for the first ten weeks and crossed over to the SG intervention in addition to treatment as usual for the subsequent ten weeks.	Virtual Twin (VT) analysis method.	Time management: Insufficient evidence that the subgroup identified using the VT method had significantly better time management skills than the entire group of participants. Planning/organizing skills: The subgroup identified by the VT method had significantly better planning/organizing skills than the whole group of participants. Cooperation skills: Insufficient evidence that the subgroup identified by the VT method had a significantly better outcome on cooperation skills compared with the total group of participants.	Time management: Insufficient evidence that the subgroup identified using the VT method had a significantly better outcome on time management skills than the total group of participants. Planning/organizing skills: The subgroup identified by the VT method had significantly better planning/organizing skills than the total group of participants. Cooperation skills: Insufficient evidence that the subgroup identified by the VT method had a significantly better outcome on cooperation skills compared with the total group of participants.

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Miclaus et al. (2020)	Non-Immersive Virtual Reality for Post-Stroke Upper Extremity Rehabilitation: A Small Cohort Randomized Trial	Received standard physiotherapy protocol included 20 to 40 minutes of VR therapy (set according to the patient's capacity) associated with dexterity exercises (occupational therapy exercises) for ten working days for two weeks.	Received a standard physiotherapy protocol of exercises and dexterity exercises for the hand (occupational therapy exercises) for a total time of 60 min	Fugl–Meyer Assessment for Upper Extremity (FMUE) Modified Rankin Scale (MRS) Functional Independence Measure (FIM) Active Range of Motion (AROM) Manual Muscle Testing (MMT) Modified Ashworth Scale (MAS) Functional Reach Test (FRT).	The results suggest that NIVR rehabilitation is efficient to be administered to post-stroke patients based on the result of the assessment tool. * Independent Kruskal–Wallis results showed that the subacute experimental group outcomes were statistically significant regarding the assessments, especially in comparison with the control groups.	Standard physiotherapy is efficient to be administered to post-stroke patients.

3.3 Characteristics of the target group

The types of target groups varied from one study to another. Three studies were conducted on stroke survivors, aged 18 to 85 years, having deficits in motor function of upper or lower extremities or both, with and without cognitive impairment (Miclaus et al., 2020; Rozental-Iluz et al., 2016; Saposnik et al., 2016). One study was done on children with cerebral palsy, aged 5 to 20 years old, with adequate balance, hand, and cognitive skills (Sajan et al., 2017). The other study was performed on children clinically diagnosed with ADHD, stable on treatment (Bul et al., 2018).(Miclaus et al., 2020; Rozental-Iluz et al., 2016; Saposnik et al., 2016). One study was done on children with cerebral palsy, aged 5 to 20 years old, with adequate balance, hand, and cognitive skills (Sajan et al., 2017). The other study was performed on children clinically diagnosed with ADHD, stable on treatment (Bul et al., 2018).

Despite a wide range of age between 5 to 85-year-old, generally, all participants in the study were those who had a deficit in motor function. Nevertheless, across all types of target groups, the participants in the intervention groups were involved with computer games in the form of Kinect-based virtual reality games or video games, or online computer games during the trial period.

3.4 Characteristics of the intervention and assessment tools

The application of computer games was seen in all the studies as sole rehabilitation intervention or as an adjunct to the conventional rehabilitation. Three interventions were using Kinect-based games with virtual reality focusing on rehabilitation of physical balance, motor function, and postural control (Miclaus et al., 2020; Sajan et al., 2017; Saposnik et al., 2016). One intervention was using a combination of Kinect based games and video games, focusing on the rehabilitation of executive function (Rozental-Iluz et al., 2016) while another intervention was using online computer games, aiming at rehabilitation of life skills of ADHD patients in (e.g., time management, planning/organizing skills, cooperation skills) (Bul et al., 2018).

All interventions were given in multiple sessions per week, within a specified duration (two weeks to three months) as determined by the researchers before the outcome being assessed.

The assessment tools used were varied, suitable, and verified for the assessed outcome dependent on the aim of the study.

4.0 Discussion

The systematic review was aimed to investigate the effectiveness of the application of computer games in healthcare. In our review, four studies conclude that application of computer games as part of the intervention in the domain of rehabilitation, are effective in patient with strokes, cerebral palsy, or ADHD as per defined in the study. In contrast, one study shows no significant difference between the intervention and control groups. We compared the articles reviewed and identified two main applications of computer games for rehabilitation: physical rehabilitation and cognitive or executive rehabilitation.

In two studies that involve patients with acute, subacute, and chronic strokes, the application of Kinect-based computer games in their rehabilitation intervention in upper extremity motor function was being investigated (Miclaus et al., 2020; Saposnik et al., 2016). Both studies use different assessment tools in measuring improvement on motor function of upper extremities. One of the studies reported favourable recovery effects seen mostly in patients less than six months post-stroke (Miclaus et al., 2020).

While Saposnik et al. (2016) reported that in those stroke patients who had mild-to-moderate upper extremity motor impairment within three months before enrolment for NIVR as an add-on therapy to conventional rehabilitation for improving motor function is not superior to recreational treatment as measured by WMFT. The study also suggests that in the rehabilitation of motor function post-stroke, the type of task used might be less relevant as it is intensive and task-specific.

In the target group that involves patients with cerebral palsy, the rehabilitation of patients' posture control, upper limb functions, and visual-perceptual skill has been monitored and analysed between intervention and control group (Sajan et al., 2017). The intervention group showed significant improvement in upper limb function, assessed by Quality of Upper Extremity Skills Test (QUEST) as similarly suggested in the studies involving stroke patients that was assessed using Fugl–Meyer Assessment for Upper Extremity (FMUE) (Miclaus et al., 2020).

Another two studies investigate the effect of interactive video games in the rehabilitation of executive function. First, the study of patients with chronic stroke suggests that they have the potential to improve as interactive video games provide combined cognitive-motor stimulation. In the study, those in the intervention group scored lower in Paying Bills Task (EFPT) during post-test, showing the need for fewer cues to complete the task, which signifies improved executive function (Rozental-Iluz et al., 2016).

The second study describes effectiveness in executive function, Bul et al. (2018) investigating moderator effect of Serious Gaming (SG) in the rehabilitation of ADHD and measuring children's planning and organising skills as one of its outcomes. They find that girls generally and boys with lower scores on hyperactivity symptoms and higher scores on Control Disorder (CD) symptoms show improvement in planning/organising skills. These results indicate that gender, level of hyperactivity/impulsivity, and presence of CD symptoms should be considered in using gaming as clinical approach and treatment of ADHD children.

Even though the application of computer games in rehabilitation is generally effective based from the articles reviewed, the significant effectiveness could only prove beneficial in specialised area, such as motor function of upper extremities (Miclaus et al., 2020; Sajan et al., 2017; Saposnik et al., 2016), or specified target group such as subacute stroke (Miclaus et al., 2020) and girls or boys with a certain level of impulsivity (Bul et al., 2018). Conventional rehabilitation intervention might be as effective, cheaper, readily, and easily available. However, compared to traditional rehabilitation intervention, computer games' cost-efficiency, accessibility, safety, usability, feasibility, and overall superiority requires further exploration.

It is momentous to note the limitations of this review, particularly concerning the materials and methods used. As this review aimed at the latest available literature (from 2016-2020) in regards of the effectiveness of computer games application in patient rehabilitation, limited databases

were obtained. Methods using electronic devices other than computer games such as mobile games or other applications were not explored further. Nonetheless, articles published in different languages or qualitative studies were not reviewed, due to language barrier and limited availability of the literatures.

5.0 Conclusion and recommendation

Our review concludes that the application of computer games is generally effective in rehabilitation based on the findings in the researched articles. The application of computer games for healthcare in rehabilitation has the potential to be a standard part of components in rehabilitation intervention. However, the overall superiority of such intervention compared to conventional rehabilitation is yet to be established. This provides opportunities for future research on using gaming as one of the better options in rehabilitation intervention.

Declaration

The authors have no conflict of interest to declare. This review has been submitted to Universiti Putra Malaysia, Serdang, Malaysia in partial fulfilment of the requirements for the Degree of Master of Public Health. Opinions, interpretations, conclusions, and recommendations are those of the authors.

Authors contribution

Author 1: information gathering, preparation and editing of manuscript
Author 2: information gathering, preparation and editing of manuscript
Author 3: information gathering, preparation and editing of manuscript
Author 4: final review of manuscript and final editing
Author 5: final review of manuscript and final editing

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