Effect of Exergame on Post-stroke Management: A Literature Review

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Abstract. Exergame has been used as a good intervention for post-stroke motor and balance problems in many literatures, but some studies show that exergame is more beneficial for cognitive than post-stroke motor problems. The purpose of this review is to ascertain the effectiveness of exergame in the treatment of stroke. A literature review was used in this study. PubMed, ScienceDirect, and PEDro databases were used for study searches. The data used ranges from 2012 to 2022 and includes the keywords "exergame" and "stroke." The study used the RCT method, and the article as a whole was reviewed through inclusion criteria for the patient they were able to follow instructions and having a stroke for more than six months. The effect of exergame in post-stroke management was determined using PICO analysis (population or problem, intervention, comparison, and outcome). A total of seven articles met the criteria, with an average PEDro score of 6.1. Exergame can help stroke patients advance in terms of cognitive, motor coordination, and balance. Exergame for the intervention showed an increase in balance as measured by the Berg Balance Scale (BBS), Time Up and Go Test (TUG), Fugl-Meyer Assessment (FMA), Posturography, and Four Step Square Test (FSST). Cognitive Abilities Screening Instrument Chinese Version (CASI C-2.0), Cognitive task (dual-task). Motor using the Fugl- Meyer Assessment-UE (FMA-UE), Motor Activity Log (MAL), and FSST (Four Step Square Test). Exergames can help post-stroke patients improve their balance, motor skills, and cognitive abilities.

Keywords: exergame · stroke · cognitive · balance · motor coordination

1 Introduction Section

Worldwide, stroke is the second most common cause of death and disability [1]. Stroke also contributes to the cause of falls in the elderly population, causing changes in balance and disrupting daily activities [2]. Annually, there are around 795,000 strokes in the United States, and 75% of stroke sufferers have lost their motor skills, increasing their risk of falling [3].

The most significant neurological deficits caused by stroke are loss of motor function, which leads to paralysis, pathological reflexes, and spasticity, all of which can impair mobility [4]. Patients with stroke are more likely to trip and fall, which restricts their

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ability to go about their everyday lives and interact with others. [5]. Exergame has been shown in studies to improve a variety of post-stroke cognitive functions and skills [6].

Exergame interventions are also classified as interactive games. Exergames are digital games that require body movement to play and serve as physical activity exercises [7]. With the potential to enhance a patient's cognitive performance, exergaming training incorporates cognitive stimulation as a motor skill exercise. Exergame is available on a variety of platforms, one of which is the Wii Balance Board (Nintendo Inc., Redmond, WA, United States), with one of its features being the Animal Hurdler Game, a game that teaches posture and balance through weight transfer and workouts that require standing on one leg [8, 9].

Exergame can be used in a variety of pathologies. Several studies suggest that by selecting exergaming, exergame can target exercises for specific motor control disorders and allow independent balance exercises that can be performed without physiotherapy in the future with telerehabilitation [9]. Exergame can improve stroke patients' functional levels, mobility, and balance [10, 11]. Exergames can be an efficient way to help stroke patients regain their balance and upper limb motor function [12]. However, there is literature indicating that using exergame as post-stroke therapy had no significant impact at 3-month follow-up [13], and most papers stress the need for additional clinical proof to support the advantages of exergame [14].

Therefore, the goal of this review is to determine how to effect exergame in the treatment of stroke.

2 Methods

Search strategy that includes a broad search of scientific articles published between 2014 and 2022. Articles obtained from the databases PubMed, ScienceDirect, and Pedro. Article references were manually retrieved and analyzed for relevant further study data. The keywords "exergame" and "stroke" were used to search the database. Titles were filtered and studies were identified to ensure that they met the inclusion criteria: a) English-language publication; b) Randomized controlled trial (RCT) comparing pre-intervention and post-intervention scores; and c) Patients who have had a stroke for more than 6 months; d) The patient is able to follow instructions.

The literature was reviewed using PICO analysis (population or problem, intervention, comparison, and outcome), to evaluate it, the PEDro scale was employed. An 11-item scale was created, consisting of the following, to evaluate the RCT's intrinsic validity and the quality of the methodology: The following things happened: (1) eligibility requirements were made; (2) groups were randomly chosen for the subjects; (3) the distribution was kept secret; (4) groups shared a baseline prognostic indicators; (5) blindness occurs in all subjects; (6) blindness occurs in all therapists who provide therapy; (7) all raters measuring at least one important result were blinded; and (8) over 85% of the initially allocated patients had measurements of at least one major outcome; 9) data were analyzed using "intention to treat" for at least one primary outcome for all patients for whom outcome measures were available, or, if this was not possible, the treatment or control condition was administered as assigned to all subjects; (10) representative statistical comparison findings between groups; (11) a point measurement and

a measure of at least one significant result are provided variability in this study. The other things are rated as "yes" or "no," with item (1), which relates to external validity, being the exception. There is a maximum score of 10 for each assignment. To understand the scores, ratings are utilized. Studies were rated using the following categories: Less than 4 is regarded awful, 6-8 is deemed decent, 4-5 is deemed acceptable, and 9-10 is deemed extremely good. [15].

Exergames such as Wii Fit, Jintronix System, and Game Motion Rehab AVE 3D were used in several sources of this research. Exergame has several modes that can be dedicated to training disorders in stroke patients, such as the Wii Fit exergame with Balance Bubble mode, which is used to train balance in stroke patients. In this study, several outcome measures were used, including cognitive using the Chinese version (CASI C-2.0), balance using the Berg Balance Scale (BBS), Timed Up and Go test (TUG), and Dynamic Balance Evaluation, Upper Extremity motor function using Fugl-Meyer Assessment-UE (FMA-UE), and Motor Activity Log (MAL).

3 Result

3.1 Article Seacrh Result

The electronic the search method turned up 268 items in total. Following the screening of the titles, 8 potentially relevant full texts were obtained. One article did not meet the inclusion requirements. As a result, the review included seven articles. Figure 1 shows how the study progressed from the research to the review.

3.2 Characteristics of Inclusion Included

Seven included articles included 173 participants and investigated the effects of exergame in post-stroke management to improve balance. [9, 11–13, 16, 17], cognitive [16, 17], motor [9, 12, 17, 18] after stroke. Table 1 contains more information.

3.3 Qualities

The PEDro Scale, dan has a range of values from 4 to 7, was used to grade quality. Its average score was 6,1. Table 2 shows Pedro's criteria and trial scores. All trial participants were chosen at random, were assigned to the same group at the start of the test, and reported differences in outcomes between groups using estimates and variability. Two trials used blinded assessors, three had a 15% dropout rate, and all used an intent-to-treat analysis (Table 3 and 4).

3.4 Participants

Participants suffered either an ischemic or hemorrhagic stroke, with their ages ranging from 18 to 76 on average across trials. Participants could follow instructions and had a stroke for more than six months.

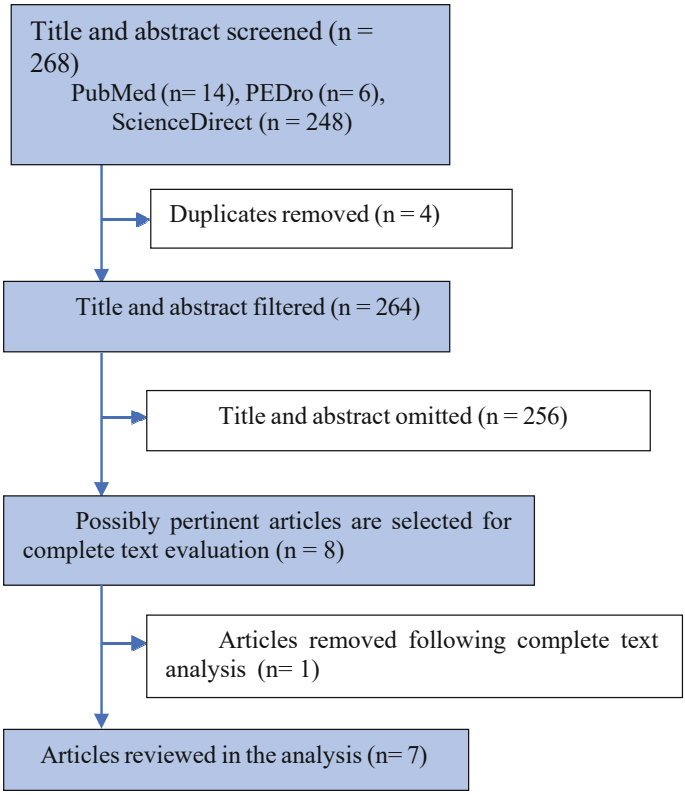

Fig. 1 The Search Strategy Flow

3.5 Intervention

Exergame

a. Wii Fit

The virtual reality system's hardware consists of a television screen and a game system; communication between the game system and the television is accomplished using the Bluetooth protocol [19]. Wii Fit can help the improvement of balance, strength, flexibility, and overall fitness [20].

b. Jintronix System

The Jintronx system from Microsoft Kinect one item that enables stroke sufferers to practice Upper Extremity and motor movements that can be adjusted to their level of ability [18].

c. Game Motion Rehab AVE 3D

Table 1. Study Characteristic

No	Author and Year	Journal	Location	Design
1	Hung et al.(2017)	European Journal of physical and rehabilitation Medicine	Taiwan	Experimental
2	Aslam et al.(2021)	Journal of the Pakistan Medical Association	Pakistan	Experimental
3	Norouzi-Gheidari et al.(2020)	International Journal of Environmental Research and Public Health	Canada	Experimental
4	Henrique et al.(2019)	Journal of Stroke and Cerebrovascular Diseases	Brazil	Experimental
5	Kannan et al.(2019)	NeuroRehabilitation	USA	Experimental
6	Hung et al.(2014)	Archives of Physical Medicine and Rehabilitation	Taiwan	Experimental
7	Cikajlo et al., 2020)	Frontiers in Psychology	Italy	Experimental

Table 2. PEDro scale

Study	Random allocation	Concealed allocation	Groups similar at baseline	Participant blinding	Therapist blinding	Assessor blinding	< 15% lost to follow-up	Intention-totreat analysis	Between-group difference reported	Point estimate and variability reported	Total (0 to 10)
(J. W. Hung et al., 2014) [13]	Y	Y	Y	Y	N	N	Y	N	Y	Y	7/10
(J. W. Hung et al., 2017) [16]	Y	Y	Y	Y	N	N	N	N	Y	Y	6/10
(Kannan et al., 2019) [17]	Y	N	Y	N	N	N	N	N	Y	Y	4/10
(Henrique et al., 2019) [12]	Y	N	Y	N	N	N	Y	Y	Y	Y	6/10
(Norouzi-Gheidari et al., 2020) [18]	Y	Y	Y	Y	N	Y	N	N	Y	Y	7/10
(Cikajlo et al., 2020) [9]	Y	N	Y	N	N	N	Y	Y	Y	Y	6/10
(Aslam et al., 2021) [11]	Y	N	Y	N	N	Y	Y	Y	Y	Y	7/10

Table 3. Subject Characteristic

No	Author and Year	Number of Subject	Subject Characteristics
1	Hung et al. (2017)	Twenty with stroke chronic hemiplegia	18 years of age, the capacity to comprehend and remember spoken instructions, good visual acuity (with necessary correction), and the capacity to function independently with or without the device are required. At least six months must pass after a stroke..
2	Aslam et al. (2021)	Thirty with stroke ischemic or hemorrhagic	Using the Modified Rankin Scale (MRS), patients between the ages of 50 and 60 were included. Participants had a score of 2–3 on the Modified Scale.
3	Norouzi-Gheidari et al. (2020)	Eighteen with stroke ischemic or hemorrhagic	Having their first ischemic or hemorrhagic stroke, having mild to moderate UE interference (scores 3–6 on the Chedoke-McMaster arm component [17]), being in a subacute or chronic stage, and receiving routine outpatient rehabilitation services at one of the two rehabilitation facilities chosen, namely the Jewish Rehabilitation Hospital and the Institut de réadaptation Gingras-Lindsay-de-Montréal, both of which are situated in Canada's greater Montreal region

(*continued*)

Table 3. (*continued*)

No	Author and Year	Number of Subject	Subject Characteristics
4	Henrique et al. (2019)	Thirty-one with stroke chronic ischemic	Diagnosis of chronic ischemic stroke (CT) longer than six months after the first stroke Age 55 or older, both sexes, not engaging in any other sex, receiving physiotherapy for stroke recovery during the intervention, receiving a total score of 19 or above on the Mini-Mental State Examination, and not experiencing any issues with auditory or visual function are all requirements.
5	Kannan et al. (2019)	Twenty-four with hemiparetic cortical stroke	Participants in the research had to have had a hemiparetic cerebral stroke more than six months prior, be aphasic-free, and have their doctor confirm the diagnosis. Participants had to be able to follow instructions in English and be able to stand unassisted for at least five minutes without the need of an assistive technology or physical support. Lunar Achilles Insight was used to quantify heel bone density, and people with a T-score of less than -2.0 were disqualified since they were considered to have osteopenia or osteoporosis.
6	Hung et al. (2014)	Thirty with hemiplegic stroke	Patients who suffered a hemiplegic stroke at least six months before to inclusion were at least 18 years old, had a Berg balance score of 56 or above, could follow verbal instructions and watch television without difficulty, and could walk unassisted to a distance of ten meters with or without a device.

(*continued*)

Table 3. (*continued*)

No	Author and Year	Number of Subject	Subject Characteristics
7	Cikajlo et al. (2020)	Twenty ischemic or hemorrhagic stroke	First ischemic or hemorrhagic stroke, initial admission to a rehabilitation program, capacity for participation and following directions (MMSE > 25), capacity for independent walking (FIM R score of at least 5).

Exergame thru immersive scenarios that explore interactions through virtual elements. The Motion Rehab AVE 3D game is intended to help stroke survivors improve their upper extremity motor function and balance.

Control Group

Conventional physiotherapy for stroke usually involves position changes, breathing exercises, passive and active mobilization exercise therapy [21]. The control group included in the article underwent the same exercises as the exercise game, including balance and motor training.

3.6 Outcome Measurements

Seven articles measured balance using the Time Up and Go Test (TUG), Berg Balance Scale (BBS), Four Step Square Test (FSST), Fugl-Meyer Assessment (FMA), and Posturography. Cognitive measurements using Cognitive Abilities Screening Instrument Cognitive task (dual-task), and Chinese version (CASI C-2.0). Motor measurements using the Fugl–Meyer Assessment-UE (FMA-UE), Motor Activity Log (MAL), and FSST (Four Step Square Test).

Effect of Exergame on Stroke

Wii Fit

The virtual reality system's hardware consist of a board game system and television. The board game system and television communicate with each other via the Bluetooth protocol [19]. Wii Fit combines using the force-platform technology, entertainment worth of playing games while engaging in physical activities, such as balance, and yoga. Wii Fit has features that are comparable to those of a force plate and includes a transducer for measuring the distribution of force and the subsequent movement of a single center of pressure (COP) [22]. The article uses a variety of games for the stroke intervention, including the Animal Hurdler game, which involves balance and posture while shifting weight and standing on one leg, the Fruit Catcher game, which involves balance and posture while stepping, and the Horse Runner game, which involves balance and posture

Table 4. Study Result

No	Author and Year	Study Result
1	Hung et al. (2017)	The percentage change in overall CASI and BBS scores did not significantly differ between the 3 groups post-intervention, at 1-month, or at the follow-up 3-month examination.
2	Aslam et al. (2021)	Exer-gaming appears to be more helpful in helping stroke patients regain their balance, mobility, and functional level. After the intervention, a noticeable improvement was seen in the exer-gaming training group.
3	Norouzi-Gheidari et al. (2020)	The function of the upper extremities can be improved with the use of the exergaming system under therapist supervision for outpatient rehabilitation treatments for stroke patients in the subacute and chronic stages. In terms of the SIS-Total score, there was a difference between the two groups ($F(1.15) = 3.9$, $p = 0.068$), and the comparison revealed that the intervention group improved more than the control group did at T1 (difference in mean = 5.7, $F(1,20.2) = 3.5$, $p = 0.077$), as well as T2 (difference in mean = 5.3, $F(1,20.2) = 3.1$, $p = 0.094$).
4	Henrique et al. (2019)	Showed substantial gains from baseline in all of the characteristics that were studied (shoulder, elbow, forearm, wrist, hand, and balance) for both groups, with a P value of 0.001. When groups were compared, there was a significant difference between the two groups for the overall ($P = 0.002$), shoulder, elbow and forearm ($P = 0.001$), and changes in scores from pre-intervention to post-intervention ($P = 0.001$).
5	Kannan et al. (2019)	Significant differences were identified by and where CMT significance level was 0.05 and CT significance level was 0.01. Under reactive DT situations post- intervention, the CMT group showed better motor and cognitive function, whereas the CT group showed improved motor function exclusively. Only the CMT group showed increased motor function under DT volitional settings.

(*continued*)

Table 4. (*continued*)

No	Author and Year	Study Result
6	Hung et al. (2014)	In the timed-up-and-go, forward reach, and fear of falling assessments, both groups shown improvement. In comparison to the control group, the exercise group had greater improvement in the stability index. At the 3-month follow-up, however, the increase in fear of falling did not persist, since the control group had improved better in terms of weight-bearing. Exercise was more enjoyable for the exergaming group than for the control group.
7	Cikajlo et al. (2020)	Both groups significantly and statistically improved their ability to maintain balance, with the exercise group doing the best (FSST $p = 0.009$, $U3 = 0.9$ and 10, MWT $p = 0.008$, $U3 = 0.9$). However, the Sharpened Romberg test ($p = 0.05$), the blinded test ($p = 0.035$), and standing on the right foot ($p = 0.035$) all revealed significant differences between the groups. The center of the pressure area was reduced by up to 20% for the exergaming group.

while strengthening muscles with a sit-to-stand exercise. Wii Fit Training (Nintendo Wii Fit = Table Tilt, Ski Slalom, Soccer Heading, Balance Bubble, Penguin Slide, Basic Step, and Warrior) dosage 12 minutes each day, twice every week for 12 weeks, cognitive-motor exergame training (Wii Fit) (Nintendo Co, Ltd. Kyoto, Japan) 20 sessions (1:3 subsessions, 4 games per subsession) lasting 5 minutes each, with 3 cognitive exercises lasting 6 weeks, and an orientation session (Goal: To understand treatment protocol), Training for anticipatory, dynamic, and static balance using the exercises "Water leaks, basic level," "Water leaks + River Rush," and "Reflex Ridge." 15 to 20 minutes It has been demonstrated that Wii Fit games enhance cognitive, motor, and balancing skills.

Jintronix System

The Jintronix System, which is based on Microsoft Kinect technology, is a gaming software created to teach unilaterally or bilaterally upper extremity motions in stroke patients. Instead of a wireless controller, this system uses the Kinect camera to capture upper body movement at varying and grading levels of difficulty [23, 24]. Jintronic employs a cable controller instead of a wireless one, in contrast to systems like the Nintendo Wii, which rely on it to track movement [25]. Tracing a horizontal or vertical path, achieving the aim, a few examples are clapping hands to grab the object between the hands and moving hands collectively to capture, transport, and dump objects, Upper

Extremity exercises that include motions against gravity. It has been demonstrated that Jintronic enhances upper extremity motor abilities.

Motion Rehab AVE 3D
A video game designed for stroke survivors with minor stroke symptoms. The Unity gaming platform, which supports Kinect motion monitoring gadgets like Smart TV 3D and Oculus Rift, was used to develop this game. This method considers six 3D motions: knee flexion, hip flexion and abduction, horizontal shoulder adduction and abduction, elbow extension, wrist extension, and shoulder flexion. The AVE 3D Rehab game can aid with balance, motor function, and upper extremity strength [26].

4 Discussion

Exergame-based exercise for stroke is a safe and effective treatment, according to this systematic review's high-quality data tool for improving balance, motor, and cognitive abilities. It is supported by several articles that have been evaluated using the PICO and Pedro Scales. Exergame has been shown to enhance balance, motor skills, and cognitive abilities using game-based exercises that make use of cutting-edge technologies, including Wii Fit, Jintronik, and Game Motion Rehab 3D. However, the exergame with Jintronix technology and Game Motion Rehab 3D improves upper extremity function even further. Jintronic technology has been proven to enhance not just upper extremity motor function, but also mobility as tested by the SIS (stoke impact scale) and activities of daily living (as measured by the MAL-QOM) (motor activity log-quality of movement) [18]. Game Motion Rehab 3D focuses on improving upper extremity balance and motor function [12]. Wii Fit technology improves balance, motor skills, and cognitive abilities. The patient's intrinsic motivation factor contributed to the increase [27].

According to two reviews in this article's analysis, exergame provided a significant improvement at one-month follow-up but no significant improvement at three months follow-up. The study of [16] Hung et al. (2017) found significant changes in balance and cognition after one month, but not after three months. The previous study found an increase in timed-up-and- go tests, forward reach, and fear of falling at one-month follow-up, but fear of falling did not last three months.

Exergame may be beneficial since it has qualities such as goal-oriented activities and repetition, both of which have been found to be helpful in neurological rehabilitation [28]. Exergame can be a revitalization technology in the health sector that needs to be developed because some literature shows that exergame improves not only motor skills, but also cognitive skills. Exergame will eventually enable independent balance training through home care or telerehabilitation [29]. Exergame attractiveness is important in terms of rehabilitation outcomes [30]. The benefits of exergame technology for assessing balance and posture have been clinically proven [31]. Exergame can also be used to treat specific motor control disorders, and patients who receive exergame intervention report that they enjoy the process more [9].

In this review of the literature on the benefits and limitations of exergame, seven articles agree that exergame can improve motor, balance, and cognitive development in stroke patients [9, 11–13, 16–18]. However, two journals reported an increase at

one- month but not three-month follow-up [13, 16]. According to one article, exergame produced results comparable to conventional training [9].

This review discusses the various functions of exergame in assisting with the management of post- stroke patients. The 7 trials included in this review had a mean PEDro score of 6.1, indicating moderate quality. The stroke inclusion criteria were more than six months and the patient's ability to follow instructions. Not all of the effects of exergame were maintained in this review; there were two articles that had good results but were not maintained at a 3-month follow-up, not all articles were of good quality, one article indicated sufficient quality, so more research on exergame for stroke patients is needed. However, the findings indicate that exergame can be used for intervention.

5 Conclusion

In conclusion, the use of exergame in stroke has been shown to improve balance, motor, and cognitive function in stroke, with a very significant effect in improving balance, and in two articles the results showed improved outcomes but were not maintained at the three-month follow-up. Exergame was recommended for stroke survivors who are able to understand instructions with mild to moderate conditions.

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