Effect of Using Mobile Games on Patients with Acute Stroke during Cognitive Rehabilitation at the Intensive Care Unit

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Abstract

Background: *Using mobile games during the rehabilitation phase of patients with acute stroke will have a progressive influence on cognitive and memory impairment, which will reduce costs and enrich their prognosis.* ***The aim of the study*** *to evaluate the effect of using mobile games on patients with acute stroke during cognitive rehabilitation at the intensive care unit.* ***Design:*** *A quasi-experimental research design (pretest and posttest research designs).* ***Setting****: The study was conducted at the neurological intensive care unit at Assuit University Hospital, Egypt****. Methods:*** *Fifty patients with acute stroke were chosen randomly; they ranged in age from 18 to 60 years old, were able to write and read, and had recently been diagnosed with an ischemic or hemorrhagic stroke.* ***Tools****: Two tools were used, the general patient's assessment questionnaire and the Montreal Cognitive Assessment (MOCA), to assess the acute stroke patients' cognitive abilities before and after the application of mobile games.* ***Results:*** *More than half of patients with acute stroke had mild cognitive impairment (58%) before application of mobile games, and the majority of them had normal cognitive ability after application of mobile games (100%). There were statistical significance differences in cognitive assessment between patients before and after the mobile game application (P value = 0.001**).* ***Conclusion****: Patients with acute stroke had better cognitive and memory functions after playing mobile games.* ***Recommendations:*** *Incorporating brain games into the rehabilitation protocol to improve cognitive function in patients with acute stroke at the ICU will produce significant results and shorten the length of stay.*

Keywords: Mobile games – patient- acute stroke - cognitive rehabilitation- intensive care unit

Introduction

Stroke is a clinical syndrome defined as an acute focal neurological deficit with a vascular basis. Stroke is accountable for cognitive impairments and motor deficits resulting from brain damage. Acute stroke typically affects the parietal, frontal, midbrain, or brainstem structures and can result in language, attention, memory, and executive dysfunctions, which can have a significant impact on daily life activities **(Ali & Arumugam, 2021).**

Acute strokes have to be cured as medical emergencies. When an individual suffers a stroke, the time between treatment and the start of nursing rehabilitation is critical. The application of planned nursing care and rehabilitation programs has had a significant impact on decreasing death and disability following stroke attacks **(Marquina et al., 2021).** Gamification is being used successfully by critical care nurses for the rehabilitation of acute stroke patients. Gamification is the practice of using game-design features and game principles to approximately encourage participation by increasing task repetition intensity **(Xu, F., et al., 2016)**.

At the intensive care unit (ICU), patients with acute stroke frequently need inspiration to start memory and cognitive rehabilitation measures **(Xu, F., et al., 2020)**. Game-based cognitive training has been recognized as a great consideration in the clinical and research communities. Many games are designed for a primary purpose other than entertainment and enjoyment, such as educating, advising, and enhancing patients' health-related conditions **(Jung et al., 2020).**

Including games in the rehabilitation phase of patients with acute stroke at the ICU provides them with intrinsic as well as extrinsic motivation. Intrinsic motivation arises from within patients as a desire and pleasure from playing games. The external motivation is the one that comes from outside: the sense of completing a level and progressing to the next one; rewards, points, symbols, and so on; all of these influences and motivate patients to participate in such games **(Adlakha et al., 2020).**

A variety of interventions have been explored by the researchers to improve cognition and memory among patients with acute stroke at the ICU. One of which is computerized cognitive training programs such as Neuro Nation games, which can provide various cognitive benefits such as improved response to time, enhanced mental flexibility, better spatial recall, and improved attention capability. The mobile game grasps patients' attention, solves problems, reasons, reads, and learns through improved cognitive abilities, and helps them develop new information by taking that data and distributing it into the appropriate areas of the brain **(Ansado et al., 2021).**

Nurses have been described as key players in interdisciplinary ICU stroke rehabilitation teams. Nursing stroke rehabilitation is described positively by patients admitted to ICUs. Nurses have struggled to define their rehabilitation role for stroke patients. "Nurses make patients' rehabilitation simpler by maintaining body functions, continuing multiple treatments, and supporting and helping patients understand and integrate new learning skills into their everyday events" **(Loft et al., 2019).**

Significance of the study:

Stroke is the third leading cause of death worldwide, and disability is a major source of morbidity and mortality. Acute stroke affected approximately 800,000 people in the United States, accounting for approximately one in every 19 deaths **(Simpkins et al., 2021).** A quarter of the population was almost affected by an acute stroke during their lifetime, and the expected annual incidence of new stroke cases is about 15 million. Also, as many as 5 million deaths and an additional 5 million permanent disability cases occurred. Ischemic stroke claimed over 39 million disability-adjusted life years worldwide in 2010. Rehabilitation should be implemented under nursing and staff supervision **(Benjamin et al., 2019).**

Aim of study:

The current study aimed to evaluate the effect of using mobile games on patients with acute stroke during cognitive rehabilitation at the intensive care unit

Research hypothesis:

Critical patients with acute stroke who received mobile game rehabilitation show cognitive improvement by using the Montreal Cognitive Assessment (MOCA) scale.

Materials and Method

Materials

Research Design:

A quasi-experimental research design (pretest and posttest) was used in the current study**.**

Setting:

The current study was applied in the Neurological Intensive Care Unit at Assuit Main University Hospital, Egypt.

Subjects:

A purposive sample of approximately fifty patients with acute stroke were randomly selected, and they met the following inclusion criteria: patient age from 18 to 60 years old, ability to read and write, use of a smart mobile phone, newly admitted, and recently diagnosed with ischemic or hemorrhagic stroke. The patient's level of consciousness ranged from 11 to 15 using the Glasgow coma scale (GCS). Data were collected between August 2020 and August 2021.

Tools: The current study used two tools. **First Tool: A General Acute Stroke Patient's Assessment Questioner** was prepared by the researchers after reviewing the related literature **(Jung et al., 2020; Oliveira et al., 2014)** to assess the following items: **Part one:** the socio-demographic data, of patients with acute stroke such as age, sex, and level of education history of any respiratory, cardiovascular, endocrine, or genitourinary disease, in addition to the patients' stroke type and ICU length of stay.

Part two: the Glasgow coma scale (GCS) used to assess the level of consciousness of patients with acute stroke was adopted from **Teasdale et al. (2014).** Which includes three partitions that are eye-opening: four items from 1 to 4, the verbal response of five items from 1 to 5, and the motor movement response of six items from 1 to 6. The lower score of 3 means "deep coma," and a higher score of 15 means "fully conscious."

Tool two: the Montreal Cognitive Assessment (MOCA) scale, adopted from **Nasreddine et al. (2005).** The entire score is 30 points, divided as follows: visuo-spatial and executive functioning (5 points), animal naming (3 points), attention (6 points), language (3 points), abstraction (2 points), delayed recall short-term memory (5 points), and orientation (6 points). MOCA is used to assess cognitive abilities such as attention, concentration, executive functions, memory, verbal and visual skills, conceptual thinking, calculations, and orientation. It is a rapid screening tool for mild cognitive dysfunction. MOCA's scoring system is as follows: a score of 26 or higher is considered normal, a score of 18-25 is considered mild cognitive impairment, a score of 10-17 is considered moderate cognitive impairment, and a score of less than 10 is considered severe cognitive impairment.

Method

Permission to conduct the study and using the mobile phone at the neurological ICU was obtained from the hospital director, the head of the stroke ICUs and the head nurse after explanation of the aim of the study.

A pilot study: was conducted on five patients with acute stroke who meet the inclusion criteria to test the tools for clarity, objectivity, and feasibility, then necessary modifications were done and the results were excluded from the study results.

Data collection: The current study was conducted after the acute stroke acute stroke patients' condition had stabilized after 24 hours of admission. The current study included four phases, assessment, preparation, implementation, and evaluation.

Assessment phase: All patients in the study were examined after stabilization of their conditions at the ICU using Tools 1 and 2 before the application of mobile games to provide baseline data on patient cognitive abilities.

Preparation phase: the researchers used a Samsung Galaxy Note Pro mobile device with Neuro Nation brain training rehabilitation games pre-installed. Neuronal games are basic and vital for cognitive processes as memory and attention underline various aspects of vital cognitive function, such as orientation, registering, memory, and language.

The researchers selected six games, which included three games designed to enhance acute stroke patients' visuospatial, memory, and orientation skills and three other games designed to increase patient attention and language skills. The six games had diverse difficulty levels, where level one was the easiest and level six was the most difficult. The difficulty levels of the six games were adjusted by changing game-specific variables, such as the number of game items, the length and pattern of the temporal sequence of the items, and the complexity of their visual characteristics.

Implementation phase: For each included patient with acute stroke, they were allowed to demonstrate the mobile games for thirty minutes per day, three days per week, for three months. During each thirty minutes session, participants spent five minutes on each of the six games.

During the early rehabilitation phase, the patient began the Neuro Nation mobile game at level one in each game and progressed to later levels until the 6th as users successfully completed the tasks. In each level, patients were given three chances to select the correct answer. If patients failed to provide the correct answer, the difficulty level was automatically reduced by moving to the previous, easier level. Each game has a predefined time limit of five minutes, which the patient must use up to automatically proceed to the next game**.** Critical patient with acute stroke did not receive any additional cognitive rehabilitation therapies other than standard routine medical and nursing care in the stroke ICU.

Evaluation phase: All patient with acute stroke included in the study were evaluated using tool two, "The MOCA scale," immediately after finishing 3 months of mobile game rehabilitation to measure the effectiveness of mobile games on their cognitive functions during the rehabilitation phase at the ICU.

Ethical considerations were achieved through the researchers' explanation of the purpose of the study. Patients were assured that the purpose of this study was to improve their cognitive functions. After discussing the study idea in its monthly meeting (20) code number (20) at 2372020, the ethical committee of the Faculty of Nursing Assuit University was granted official ethical permission to conduct the study.

Patient-written informed consent was taken after explanation of the study idea and its aim. The patients were also informed that their data were considered confidential, that their data would not be used in any further research without the patient’s permission, and that they had the right to withdraw from the study at any time without further explanation.

Statistical analysis

Data were computerized using the Statistical Package for the Social Sciences (SPSS) version 25. All data in this study are analyzed and distributed in descriptive statistics as numbers and percentages. Mean and standard deviation were used as measures for quantitative data. Regarding analytical statistics, an independent t-test was used to test the significant differences in quantitative variables. Moreover, the Chi-Square test of independence was used to test the significance of the results of categorical variables.

Results:

The current study results presented in the following order:

Table 1: The age group was 46% between 28-38 years and 42% between 38-48 years. It was found that 66 % of the study patients were male and was 76% were university degrees. In terms of length of stay, 52 % of patients stayed in the neurological ICU for 8-14 days, while 38 % stayed for 1-7 days. The stroke type were 70% of patients has an ischemic stroke. It was found that 48% and 40%, respectively, of stroke patients have atrial fibrillation and hypertension, while 44% of stroke patients have hyperglycemia. Concerning the level of consciousness, it was found that 52 % and 48 % respectively, of the stroke patients had GCS scores of 11–15.

Table 2: It was discovered that 48.0% of patients scored 1 out of 5 in terms of visuospatial or executive function prior to the application of mobile games, and 62.0 % scored 4 out of 5 after the application. After assessing the ability of patients to name objects, it was found that 94% had a score of 3 from 3 and 64% had a score of 6

from 6 after the mobile game application. Concerning the patients' ability to repeat the words, 52.0% of them had a score of 1 from 3 before application, and 52.0% had a score of 3 from 3 after application, the abstraction 92.0% had 2 from 2. Concerning patient delayed recall, 40.0% had a score of 1 out of 5 before mobile games and 70.0% had a score of 5 out of 5 after games rehabilitation. We received 6 out of 6 for patient orientation in 50% following the mobile game application. There was a statistically significant difference in the MOCA scale between the studied patients before and after the application of mobile games (P 0.001**).

Table 3: In terms of the memory of the patients studied, following the use of mobile games, 84% of the participants were able to recall the words heard from the researcher (memory from the first trial). Before the application of mobile games, 88% of patients remembered some words after the researcher repeated and read the same words more than once (memory from the second trial). In critically ill patients, there were statistically significant differences before and after using memory-enhancing mobile games (P value = 0.001**).The same table revealed that 58% of patients had mild cognitive impairment before the mobile game and 100% had normal cognitive ability after the application of mobile games, There were statistically significant differences in cognitive assessment between acute stroke patients before and after using mobile games (P = 0.001**).

Table 4: Explain the relationship between the mean score of the patient with acute stroke, level of cognitive assessment before and after application of mobile games and their demographic data. It was found that statistically significant difference between the mean score of patients' age and cognitive level before the application of mobile games (P-value 0.003). While there was no statistically significant difference between the mean scores of patients' age, sex, and level of education after the application of mobile games.

Table 5: Depicts the relationship between the mean score of the cognitive assessment level of the patients studied before and after the application of mobile games and their clinical data. There were statistically significant differences in the level of consciousness and cognitive level prior to the application of mobile games (P-value = 0.003**).

Table 1: - Distribution of studied critically ill patients according to demographic and clinical data (n=50)

Demographic data	No	%
Age		
28-38 years	23	46.0
38-48 years	21	42.0
48-60 years	6	12.0
Sex		
Male	33	66.0
Female	17	34.0
Level of education		
University	38	76.0
Secondary	12	24.0
Clinical data		
Length of stay		
1-7 days	19	38.0
8-14 days	26	52.0
15-21 days	5	10.0
Type of stroke		
Ischemic	35	70.0
Hemorrhagic	15	30.0
History of cardiovascular disease		
Hypertension	20	40.0
Myocardial infraction	6	12.0
Atrial fibrillation	24	48.0

Demographic data	No	%
History of respiratory disorder		
Chronic Obstructive Pulmonary Disease (COPD)	12	24.0
None	38	76.0
Metabolic disorder		
Hyperglycemia	22	44.0
None	28	56.0
Genitourinary system		
Urinary tract infection	2	4.0
Renal failure	6	12.0
None	42	84.0
Level of consciousness (GCS)		
From 11-13	26	52.0
From 13-15	24	48.0

Table 2 :-Comparison between patient with stroke before and after mobile games rehabilitation related to Montreal Cognitive Assessment (MOCA) scale (n=50).

Montreal Cognitive Assessment scale	Before mobile games rehabilitation		After mobile games rehabilitation		P. value
	No	%	No	%	
Visuospatial/executive					
1	24	48.0	0	0.0	<0.001**
2	18	36.0	0	0.0	
3	8	16.0	0	0.0	
4	0	0.0	31	62.0	
5	0	0.0	19	38.0	
Naming					
1	31	62.0	0	0.0	<0.001**
2	19	38.0	3	6.0	
3	0	0.0	47	94.0	
Attention					
1	3	6.0	0	0.0	<0.001**
2	9	18.0	0	0.0	
3	30	60.0	0	0.0	
4	8	16.0	1	2.0	
5	0	0.0	17	34.0	
6	0	0.0	32	64.0	
Language					
0	11	22.0	0	0.0	<0.001**
1	26	52.0	0	0.0	
2	13	26.0	24	48.0	
3	0	0.0	26	52.0	
Abstraction					
0	43	86.0	0	0.0	<0.001**
1	7	14.0	4	8.0	
2	0	0.0	46	92.0	
Delayed recall					
0	5	10.0	0	0.0	<0.001**
1	20	40.0	0	0.0	
2	18	36.0	0	0.0	
3	7	14.0	1	2.0	

Montreal Cognitive Assessment scale	Before mobile games rehabilitation		After mobile games rehabilitation		P. value
	No	%	No	%	
4	0	0.0	14	28.0	
5	0	0.0	35	70.0	
Orientation					
1	24	48.0	0	0.0	<0.001**
2	21	42.0	0	0.0	
3	5	10.0	0	0.0	
4	0	0.0	4	8.0	
5	0	0.0	25	50.0	
6	0	0.0	21	42.0	

Chi square test for qualitative data between the two groups
****Significant level at P value < 0.01.**

Table 3:- Comparison between memory and cognitive impairment of the patient with stroke before and after mobile games rehabilitation (n=50)

Memory / Cognitive assessment level	Before mobile games		After mobile games		P. value
	No	%	No	%	
Memory					
Memory First trial	6	12.0	42	84.0	<0.001**
Memory second trial	44	88.0	8	16.0	
Cognitive Assessment level					
Normal	0	0.0	47	94%	<0.001**
Mild	29	58.0	3	6%	
Moderate	21	42.0	0	0.0	
Mean+SD	10.26+2.33		27.40+1.56		<0.001**

Chi square test for qualitative data between the two groups. Independent T- test for quantitative data between the two groups **Significant level at P value < 0.01

Table 4:- relationship between mean score of stroke patient's cognitive impairment before and after mobile games rehabilitation and their demographic data (n=50)

Items	No	Cognitive assessment level			
		Before mobile games rehabilitation		After mobile games rehabilitation	
		Mean ± SD	Range	Mean ± SD	Range
Age					
28-38 years	23	10.48±2.94	6-17	27.09±1.76	23-30
38-48 years	21	9.48±1.33	7-12	27.86±1.35	25-30
48-60 years	6	12.17±0.98	11-13	27±1.26	25-28
P. value		**0.033***		**0.215**	
Sex					
Male	33	9.82±1.99	6-15	27.21±1.36	25-30
Female	17	11.12±2.74	8-17	27.76±1.89	23-30
P. value		**0.061**		**0.241**	
Level of education					
University	38	10.16±2.07	6-15	27.32±1.66	23-30
Secondary	12	10.58±3.09	7-17	27.67±1.23	26-30
P. value		**0.586**		**0.504**	

Independent T- test for quantitative data between the two groups . One way Anova test quantitative data between the Three groups or more. *Significant level at P value < 0.05, **Significant level at P value < 0.01

Table 5: - Relationship between mean score of stroke patient's cognitive impairment before and after application of mobile games rehabilitation and their clinical data (n=50)

Clinical data	N	Cognitive assessment level			
		Before mobile games rehabilitation		After mobile games rehabilitation	
		Mean ± SD	Range	Mean ± SD	Range
Length of stay					
1-7 days	19	9.95±1.81	8-15	27.26±1.52	25-30
8-14 days	26	10.46±2.32	6-16	27.62±1.44	25-30
15-21 days	5	10.4±4.16	7-17	26.8±2.39	23-29
P. value		**0.765**		**0.513**	
Type of stroke					
Ischemic	35	10.26±2.42	7-17	27.26±1.58	25-30
Hemorrhagic	15	10.27±2.19	6-16	27.73±1.53	23-30
P. value		**0.990**		**0.329**	
History of cardiovascular disease					
Hypertension	20	10.25±2.02	7-16	27.6±1.47	23-30
Myocardial infraction	6	9.17±1.47	8-12	26±2	25-30
Atrial fibrillation	24	10.54±2.7	6-17	27.58±1.41	25-30
P. value		**0.442**		**0.062**	
History of respiratory disorder					
Chronic obstructive pulmonary disease (COPD)	12	10.08±1.24	8-12	27.92±1.08	26-30
None	38	10.32±2.59	6-17	27.24±1.67	23-30
P. value		**0.766**		**0.192**	
Metabolic disorder					
Hyperglycemia	22	10.45±1.74	7-13	27.55±1.22	25-30
None	28	10.11±2.73	6-17	27.29±1.8	23-30
P. value		**0.606**		**0.566**	
Genitourinary system					
Urinary tract infection	2	9±0	9-9	27.5±0.71	27-28
Renal failure	6	12.17±0.98	11-13	27±1.26	25-28
None	42	10.05±2.39	6-17	27.45±1.64	23-30
P. value		**0.081**		**0.806**	
Level of consciousness (GCS)					
From 11-13	26	9.35±1.74	6-13	27.31±1.26	25-30
From 13-15	24	11.25±2.51	8-17	27.5±1.87	23-30
P. value		**0.003****		**0.669**	

Chi square test for qualitative data between the two groups, *Significant level at P value < 0.05

Discussion

A stroke is responsible for both cognitive and motor impairments resulting from brain damage. Post-stroke impairments are caused by damage to the parietal, frontal, midbrain, or brainstem structures and can manifest as language, attention, memory, and executive dysfunctions, which can have a significant impact on daily activities **(Oliveira et al., 2014).** Post-stroke patients with cognitive impairments often experience difficulty attaining independent living, which results in an increased rate of hospitalization and cost of care **(Jung et al., 2020).**

Acute stroke impairment has a great effect on everyday life and may lead to poor cognitive recovery after stroke. Creating efforts to improve these functions is highly relevant **(Van De Ven et al., 2017).** Starting ICU as soon as possible Game-based rehabilitation is an emerging therapeutic intervention that allows intensive, repetitive, task-based training to improve cognitive function following stroke **(Hussain et al., 2018),** so the present study was done to evaluate the effectiveness of using mobile games on acute stroke patients' cognitive rehabilitation at the intensive care unit.

In terms of patient socio-demographic data, the current study found that less than half of the fifty newly diagnosed patients with acute stroke at the ICU were in the middle age group. But with regard to sex, it was found that most stroke patients were men. The researchers related the present result to the non-modifiable risk factors of stroke disease, such as age and sex. Acute stroke is more common in men in the middle age group due to stress and cigarette smoking among this age group.

The present study result was in line with **Boehme et al.'s (2017)** finding that recent evidence suggests that ischemic stroke incidence and prevalence have been increasing in the age groups between 20 and 54 years old. Another study by **Li, B., et al. (2015)**, not in the same context as the current research, found a relationship between sex and stroke risk depending on age and that young women have a high risk of stroke similar to men.

Regarding patient clinical data, the present study displays that the majority of the study patients had an ischemic stroke. The current study results are in good agreement with other studies **Sedova et al., (2021)** that have revealed that ischemic stroke is the most common type of stroke, followed by the intra-cerebral hemorrhagic stroke type. **Kolominsky-Rabas et al. (2015)** are consistent with the present study when they state that more than half of all the stroke types were ischemic strokes. As mentioned above in the study results, the studied sample's past medical history revealed that less than half of stroke patients had atrial fibrillation and hypertension. On the other hand, less than half of them had a history of diabetes mellitus with uncontrolled hyperglycemia.

These results are consistent with other studies **Freitas-Silva et al., (2021),** which presented that less than half of the stroke patients had a history of atrial fibrillation, coronary artery disease, or diabetes mellitus. But concerning hypertension, **Freitas-Silva et al. (2021)** found that the majority of stroke patients had a history of uncontrolled hypertension. Another study is consistent with the present study **Okon et al., (2021),** in which they found less than a quarter of stroke patients had atrial fibrillation but less than half had coronary artery disease and diabetes mellitus.

The main concern of the study regarding the effect of mobile games on patient cognitive rehabilitation was to compare the effect of mobile games on cognitive rehabilitation before and after their application on critically ill patients with acute stroke using the Montreal Cognitive Assessment (MOCA) scale. Regarding patient cognitive ability, the present study discovered that more than half of acute stroke patients had mild cognitive impairment before application of mobile games, and the majority of them had normal cognitive capabilities after using mobile games. There were statistically significant differences in the level of cognitive abilities between patients before and after the application of mobile games. The data obtained are approximately steady with the major results of **Jung et al.'s (2020)** controlled randomized study that examined the therapeutic efficiency of cognitive rehabilitation using mobile games and suggest that it has yielded comparable or greater improvements in cognitive function in acute stroke patients. For instance, **Zucchella et al. (2002)** reported that acute-stage stroke survivors showed a mean improvement of 2.6 points from 22.8 to 25.5 in the cognitive and memory assessment after 16 sessions of one-hour conventional cognitive therapy using mobile applications.

Motter et al., (2019), found significant and greater improvement in the cognitive functioning, improved mood, and everyday functioning of the study groups who received computerized cognitive training. Furthermore,

Adlakha et al (2020). reported significant and greater improvement in the cognitive functioning, improved mood, and everyday functioning of the study groups who received computerized cognitive training. Furthermore, **Adlakha et al. (2020)** were in the same line as the present study in declaring that cognitive functions can be improved by using brain rehabilitation games. In addition, it also provides entertainment and literacy to the patients. Gamified rehabilitation approaches are more effective than traditional treatments. Gamified rehabilitation enhances patient engagement, socialization, feedback, and adherence to the treatment procedure and offers better health outcomes. Also, it simplifies playing with motivation and excitement.

Patient with acute stroke whom started rehabilitation through playing games makes the repetitive exercises more engaging and motivating. So the present study results about memory assessment found that the majority of patient with acute stroke were able to recall the words they heard from the researcher (memory from the first trial). Furthermore, a great percentage of them had normal cognitive ability after the application of Neuro-World mobile games during stroke rehabilitation. These results are in good agreement with **Jung et al. (2020),** who confirmed the therapeutic success of the Neuro-World rehabilitation game in improving working memory. Neuro-World games ask users to remember and reproduce a sequence of animals leaving a farm to train. Furthermore, the majority of the intervention group's participants had better memory and recall than the control group.

Valladares-Rodríguez, et al. (2016) displayed a mean improvement of 1.5 points from 5.8 to 7.3 of the Mini-Mental State Examination (MMSE) in rehabilitation after practicing serious games that are specifically designed to allow users to display a sequence of numbers and instructing users to remember and reproduce the sequence in reverse order which trains the working memory. They also reported statistically significant improvements in the Digit Forward Span (DFS) which is used in assessing the attention and working memory after conventional or game-based rehabilitation in patients with brain injury. **Kılıc, et al., (2017)** stated that game grounded rehabilitation is positively used in the early rehabilitation of neurological disorders it enhances impaired speech; remediate swallowing and chewing in such patients.

This experiment reveals that there was a statistically significant difference between the mean score of patients' age and cognitive level before the presentation of Neuro-World mobile games. There were statistically significant differences between the level of consciousness and cognitive level before the application of mobile games. Furthermore, there were significant differences between the patient history of cardiovascular diseases, metabolic disorders, and patient memory defects before and after the implementation of mobile games.

The result of the present study was in line with **Elaklouk, et al., (2015)** they described that most patients are familiar with the digital environment categorized by computers and handheld technology. Most patients with brain injuries who are younger than 35 years are fairly skillful in using computers and handheld devices. On the other hand **Laabidi, et al., (2014)** established that Information and Communication Technologies (ICT) can play a critical role in supporting the rehabilitation process for post-stroke patients at the ICU by using serious games in cognitive and physical rehabilitation. Initiating games in the rehabilitation of post-stroke patients would be precious to the rehabilitation process and offer advantages that are absent in conventional techniques, and more importantly, it would increase the effectiveness and efficiency of the rehabilitation phase.

The results thus obtained are compatible with **Ansado, et al., (2021)** that mobile games used early in stroke rehabilitation lead to improvement in cognitive functions. They reported that interaction between post-stroke patients and virtual reality games allows the active interaction and training of working memory which motivates patients and could ultimately serve as a prognostic marker for therapeutic success. **Rizzo, (2019)** conveyed a great interest in the research community in the practice of serious mobile games for neuropsychological rehabilitation of patients post-stroke at the ICU.

Finally **Muradov, et al., (2021)** established that traditional painful rehabilitation therapies cause many side effects like vomiting, and nausea but virtual games help them in distracting their mind from pain to the frolic activities. Virtual games are considered by the healthcare team as a relaxing and enjoyable technique. Virtual games have previously been verified to improve the co-creation of value and help to preserve patients' inspiration, excitement, and full of energy.

Conclusion:

Based on the results, it can be concluded that the research into using mobile games has been very successful and have many positive effects on acute stroke patients cognitive and memory function during the rehabilitation phase at the ICU.

Recommendations

Based on the findings of the current study, the following are recommended:
For nursing practice: Mobile games for rehabilitation of cognitive impairment should be routinely conducted for acute stroke patients in intensive care settings.
For nursing education: integration of new stroke rehabilitation methods such as virtual games in undergraduate students' curriculum
For nursing administration: The nurse administrator should plan and organize educational programs for nursing personnel about using mobile games for cognitive rehabilitation of acute stroke patients.

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