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ORIGINAL RESEARCH

Effects of a Video Game-Based Intervention on the Attention and Functional Independence of Older Adults after Cerebrovascular Accident

Efeitos da intervenção com game na atenção e na independência funcional em idosos após acidente vascular encefálico

Efectos de la intervención con game en la atención y en la independencia funcional en personas mayores después de accidente cerebrovascular

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ABSTRACT | The population aging is increasing the number of chronical diseases that result in cognitive and motor limitations, how stroke. The objective of the research was to investigate the effects of Motion Rehab game in attention and independence in the elderly after stroke. It is a study of control intervention before and after, where population was 10 elderly people with average ages of 67,7 and 71 years old, with cerebrovascular damage caused by ischemic stroke, and users of the Physical rehabilitation center. The research sessions were realized individually, once a week frequency, with 15 minutes long, during 15 weeks. The research tools were, Mini Mental State Examination, Functional Independence Measure, Geriatric Depression Scale and Colorful Trails Test. The research sessions were realized individually, once a week frequency, with 15 minutes long, during 15 weeks. In the data analysis the Student t test for paired samples was applied. The results determine significant differences in the attention and independence after the interventions with the game. During the colorful trails tests´ the time reduced 330,5±140,8 second at the evaluation, from 259,4±112,5 second the reevaluation (p=0,039), for more, the psychologist professional interference needs decreases from 0,8±0,5 to 0,4±0,3 (p=0,036). The Functional Independence average obtained at first was a score of 102,3 ± 23,4 (modified dependence) and at the reevaluation a score of 107±18,6 (modified independence) (p=0,044). It was possible to conclude that the interventions brought benefits to the elderly people, turning in an alternative to the physics and cognitive rehabilitations to that population.

Keywords | Aging; Stroke; Activities of Daily Living; Attention; Video Games.

RESUMO | O envelhecimento da população vem aumentando o número de doenças crônicas que resultam em limitações cognitivas e motoras, como o acidente vascular encefálico (AVE). O objetivo da pesquisa foi investigar os efeitos do game Motion Rehab na atenção e na independência em idosos após AVE. Trata-se de um estudo com intervenção controle antes e depois, em que participaram 10 idosos de ambos os sexos, com idade média de 67,7±7,1 anos, com predominância do AVE isquêmico e frequentadores de um Centro de Reabilitação Física. As sessões foram realizadas individualmente uma vez por semana, com duração de 15 minutos, em um período de 15 semanas. Os instrumentos utilizados foram o "Miniexame do estado mental", a "Medida de independência funcional" (MIF), a "Escala de depressão geriátrica" e o "Teste de trilhas coloridas". Na análise dos dados foi utilizado o teste t

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de Student para amostras pareadas. Os resultados determinaram diferenças significativas na atenção e na independência após as intervenções com o game. No teste de trilhas coloridas o tempo de execução reduziu de 330,5±140,8 segundos na avaliação para 259,4±112,5 segundos na reavaliação (p=0,039), além da interferência do profissional psicólogo também reduzir de 0,8±0,5 para 0,4±0,3 (p=0,036). A MIF teve inicialmente um escore de 102,3±23,4 (dependência modificada) e na reavaliação 107±18,6 (independência modificada) (p=0,044). Foi possível concluir que a intervenção trouxe benefícios aos idosos, tornando-se uma alternativa para a reabilitação física e cognitiva dessa população.
Descritores | Envelhecimento; Acidente Vascular Cerebral; Atividades Cotidianas; Atenção; Jogos de Vídeo.

RESUMEN | El envejecimiento de la población aumenta el número de enfermedades crónicas que resultan en limitaciones cognitivas y motoras, como el accidente cerebrovascular (ACV). El objetivo del estudio fue investigar los efectos del game Motion Rehab en la atención y en la independencia en personas mayores después de ACV. Se trata de un estudio con intervención control antes y después, en lo cual participaron 10 personas mayores de ambos los sexos, con edad media de 67,7±7,1 años, con predominancia de ACV isquémico y frecuentadores de un Centro de Rehabilitación Física. Las sesiones se realizaron individualmente una vez por la semana, con duración de 15 minutos, en un periodo de 15 semanas. Los instrumentos utilizados fueron el "Mini examen del estado mental", la "Medida de independencia funcional" (MIF), la "Escala de depresión geriátrica" y la prueba de bandas coloridas. En el análisis de datos se utilizó la prueba t de Student para las muestras pareadas. Los resultados determinaron diferencias significativas en la atención e independencia después de las intervenciones con el game. En la prueba de bandas coloridas el tiempo de ejecución disminuyó de 330,5±140,8 segundos en la evaluación para 259,4±112,5 segundos en la revaluación (p=0,039), además de la interferencia del profesional psicológico también disminuir de 0,8±0,5 para 0,4±0,3 (p=0,036). La MIF tuvo inicialmente una puntuación de 102,3±23,4 (dependencia modificada) y en la revaluación 107±18,6 (independencia modificada) (p=0,044). Se concluye que la intervención trajo beneficios a las personas mayores, siendo una alternativa para la rehabilitación física y cognitiva de esta población.
Palabras clave | Envejecimiento; Accidente Cerebrovascular; Actividades Cotidianas; Atención; Juegos de Video.

INTRODUCTION

We are currently experiencing a period marked by numerous transformations and technological advances. The quest for a more active and healthy lifestyle has stimulated various studies focusing on the older adults population and technologies as enablers of innovative experiences, such as the use of video games to stimulate the brain[1].

The emergence of new forms of rehabilitation with the use of video games has become a strong ally of health professionals, especially those directly involved in rehabilitation. The use of such technology has boosted intervention not only in healthy subjects, but also as a motivation strategy in treating patients with conditions resulting from a neurological injury, such as a cerebrovascular accident (CVA).

CVA is described as a cerebrovascular disease caused by the interruption of blood flow to the brain, and can be classified according to the presence of hemorrhage or ischemia. The interrupted supply of oxygen and nutrients causes injury to the brain tissue, provoking sequela[2].

Every year, 15 million people worldwide suffer a CVA. Of this total, five million die and another five million become permanently incapacitated, evidencing that the number of CVAs continues increasing due to aging[3].

Among the main interventions for the rehabilitation of motor sequela, researchers have included the use of technology in their protocols. The most employed and efficient proposals to treat motor alterations caused by CVAs involve Constraint-Induced Movement Therapy (CIMT), biofeedback, motor imagery, and robotic-assisted gait training[4].

Video games are considered a complementary tool in rehabilitation and have been a frequent focus of research and practice in the past few years. However, proof of their efficacy among older adults is still scarce[5].

In the study by Anguera et al.[6], video games were used with 46 adults aged 60 to 85 years over four weeks, adding up to a total of 12 hours. The authors reported that this type of intervention can be useful to evaluate the cognitive reserve of this population. More specifically, the researchers affirmed that a subject's performance in a specific video game may be a sign of cognitive decline.

On the other hand, this same method contributes to improve sustained attention and memory in the short term. These results are ratified by other authors who also affirm that the use of video games has a direct influence in the development of cognitive functions[7].

Intervention with virtual environments in CVA rehabilitation may vary, since the objectives may range from training a specific movement to improve a particular motor skill, such as placing a cup of coffee on the table, to more advanced activities with physical objects within virtual environments[8]. In both cases, qualified professionals must elaborate a treatment plan with the use of video games. It is necessary to establish relevant strategies for each individual case to cater for special needs that may involve associated risks not present in other subjects without the same pathology[9].

Within this context, other researchers show that the use of virtual environments in the rehabilitation of patients with CVA sequela is capable of achieving significant results in tests assessing cognition, gait, balance, motor control, and perception[10,11]. In addition, the use of technology is a motivating and differentiated alternative for patients in CVA rehabilitation.

Given this scenario, it is necessary to address both cognitive and motor aspects in the rehabilitation of CVA patients. With this perspective in view, the objective of this study was to investigate the effects of intervention with a video game on the attention and functional independence of older adults who had suffered a CVA. The hypothesis tested was that intervention with video games can improve attention and functional independence in these older adults. For this study, the video game *Motion Rehab* was developed in partnership with the Computing Science course of the University of Passo Fundo, Rio Grande do Sul, Brazil.

METHODOLOGY

This is a quasi-experimental quantitative study with pre- and post-control intervention.

Ethical considerations and sample

The research was approved by the Research Ethics Committee of the University of Passo Fundo, according to Resolution no. 466/2012 of the Brazilian National Health Council, opinion no. 605.652/2014. All individuals participating or persons responsible signed a free and informed consent form.

Ten older adults of both sexes took part in the study, complying with the following inclusion criteria: 60 years old or more; no serious cognitive impairment or dementia; no depression symptoms; defined CVA diagnosis in acute or chronic stage; impairment in left or right side of ischemic or hemorrhagic origin; and attending regular physical rehabilitation at the Regional Center for Physical Rehabilitation of Giruá, Rio Grande do Sul, Brazil. The older adults participating in the intervention with the video game continued their conventional physiotherapy treatment, according to the methodology adopted by the health care institution, with specific Bobath techniques.

Instruments

To investigate the inclusion criteria, the following instruments were used:

1) Mini Mental State Examination: capable of screening/identifying dementia. It verifies the integrity of cognitive functions: space-time orientation, memory, attention, calculation, language and constructional praxia[12]. The cut-off points of the version validated for the Brazilian population by Bertollucci et al.[13] and improved by Brucki et al.[14] were used, which are: illiteracy – 19 points; 1 to 3 years of schooling – 23 points; 4 to 7 years – 24 points; and over 7 years of schooling – 28 points[13].
2) Geriatric Depression Scale: tool to diagnosis depression symptoms. It is widely used in studies involving older adults, with a cut-off value above five points[16]. The scale was used to evaluate the presence of depression, which could impair the individuals' level of attention during the execution of the video game. It was administered by a professional psychologist.

Data was collected at two different moments, pre- and post-intervention, with the use of the following instruments:

1) Socio-demographic and clinical questionnaire, including age, sex, level of education, profession, marital status, income, city, urban or rural area resident. The clinical aspects considered type of CVA, affected brain side, motor skills and

time since injury. These data were collected in interviews with patients or persons responsible before the intervention. The questionnaire was prepared by the researchers based on the literature and the objective of the study.

2) Functional Independence Measure: verifies the performance of older adults in tasks such as: self-care, sphincter control, transfers, locomotion, communication, and social cognition. Dependence levels are classified as: Independence (7. Complete Independence; 6. Modified Independence); Assisted Dependence (5. Supervision or Preparation; 4. Minimal Assistance; 3. Moderate Assistance); and Complete Dependence (2. Maximal Assistance; 1. Total Assistance)[15].
3) Colored Trails Test: Brazilian adaptation by Rabelo et al., used for attention evaluation. It is divided into two subtests, one assessing sustained attention and the other divided attention. It was administered individually by a psychology professional. It also enables measurement of the interference between sustained and divided attention.

The Motion Rehab video game

The video game (industrial property registration number BR 51 2014 001087-2) was developed based on a protocol prepared by the researcher containing the following exercises: shoulder flexion and abduction; elbow extension; hip and knee extension and flexion.

It takes 15 minutes, with activities distributed into four phases (Figure 1 and 2), based in the main limitations caused by CVA and considering different methodologies available for the physical and cognitive rehabilitation of this injury.

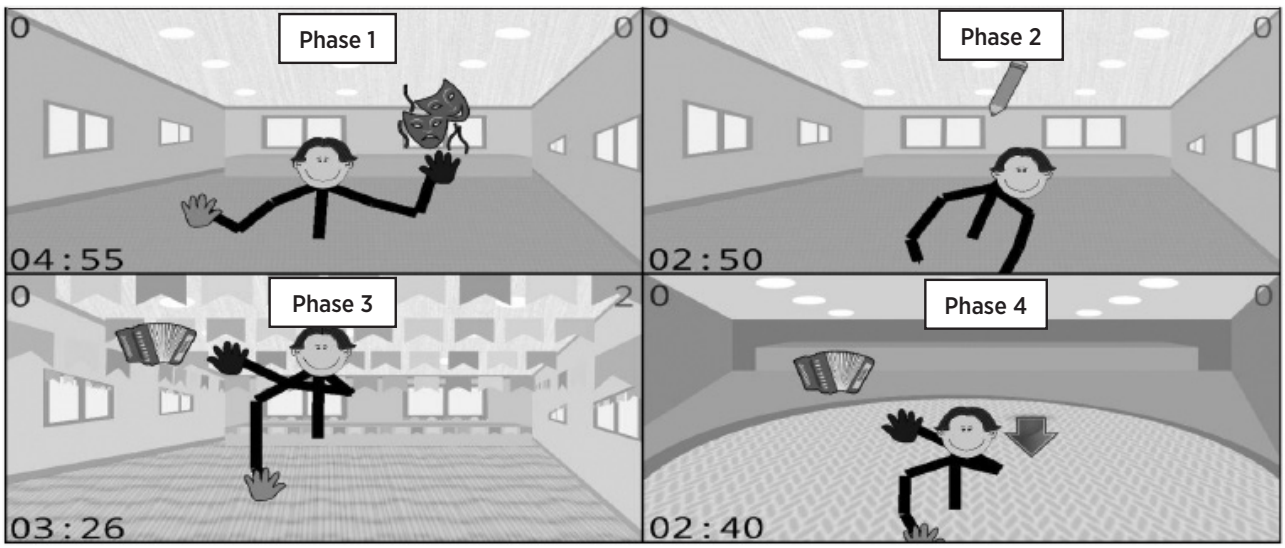

Figure 1. Phases of the Motion Rehab video game

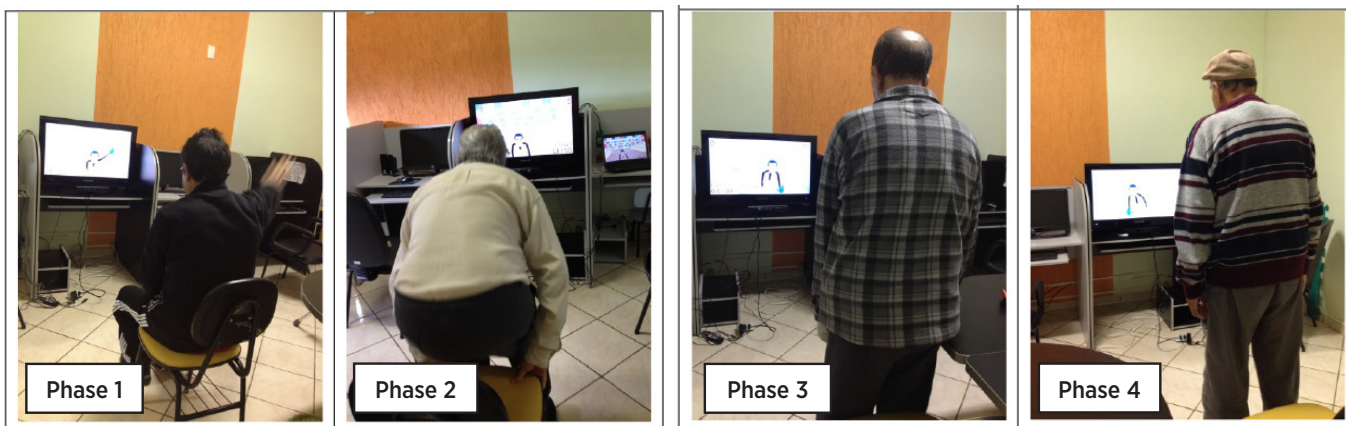

Figure 2. Phases of the Motion Rehab video game with participants

Phase 1 involves exercises for the upper limbs with subjects sitting on a chair (five minutes). Phase 2 involves sitting and standing exercises, with subjects looking for the objects with their head (three minutes). Phase 3 involves exercises with upper limb movements and slight torso rotation, with subjects standing (four minutes). Phase 4 combines all previous exercises in one (three minutes).

The setting of *Motion Rehab* is a dance for older adults, with music typically played at this kind of leisure event. The subject must move his hand or head in the direction of objects that correspond to the game's theme, scoring points when successful. Distractors (objects unrelated to the context) appear among these objects, making subjects lose points when they are touched.

Video games used in rehabilitation offer different levels of difficulty. Normally, the game is more difficult when the execution pace is faster and easier when the pace is slower[18]. The configurations provided by *Motion Rehab* include level of difficulty, consisting of increasing the speed with which objects appear on the screen.

The game was developed with Microsoft Visual Studio 2010 IDE, XNA 4.0 framework and Kinect for Windows SDK 1.7 library for use of the Kinect movement sensor. It was created in partnership with the Computing Science course of the University of Passo Fundo, Rio Grande do Sul, Brazil.

Procedures

Initially, the instruments to assess inclusion criteria and data collection were administered.

The intervention sessions were held individually once a week, over a period of 15 weeks, totaling 15 sessions. Subjects remained with the researcher for a total period of 45 minutes, allowing time to check vital signs (blood pressure, heart rate and oxygen saturation) at the beginning and end of the session and for their movement requirements. The participants also continued with their normal treatments.

All intervention sessions were supervised by the researcher responsible for the study.

The older adults interacted with the *Motion Rehab* video game via a 32" TV connected to a computer and the Kinect movement sensor (located below the TV), a device that recognizes human body movement through a camera with RGB video capture; a depth sensor; an infrared sensor to capture spatial movement; and a microphone for voice command.

All participants were reassessed after the final session.

Data analysis

Data were captured on a Microsoft Excel table and the statistical analysis was performed with the aid of SPSS 17.0 for Windows. Numerical variables were expressed as average ± standard deviation or median (percentile 25 – 75) according to normal or non-normal distribution, and categorical variables as absolute and relative frequency. Pre- and post-intervention comparisons were executed using Student's t-test for paired samples. Tests with a probability value of < 0.05 were considered statistically significant.

RESULTS

Table 1 shows the socio-demographic and identification characteristics of the participants' clinical aspects. Of the total number of participants, whose average age was 67.7±7.1, five (50%) were male and five (50%) were female, nine (90%) of them married. Regarding residence, 9 (90%) lived in the urban area; among these, the prevailing profession prior to the CVA was agriculturist – five (50%). We should stress that before the CVA most of them lived in the rural area, but the need for medical care and regular treatment forced them to move to the city.

Regarding the clinical factors of the brain injury, ischemic CVA was more prevalent, affecting eight (80%) of the older adults, and the most injured brain side was the right one, affecting five (50%) of them.

Table 1. Socio-demographic characteristics of the studied population (n=10)

Variable	Statistic
Male	5 (50%)
Average age	67,7±7,1
Marital status	
Married	9 (90%)
Widowed	1 (10%)
Level of education	4,7±2,6
Type of CVA	
Hemorrhagic	2 (20%)
Ischemic	8 (80%)
Affected side	
Right	5 (50%)
Left	3 (30%)
Bilateral	2 (20%)
Motor dominance	
Right	5 (50%)
Left	5 (50%)
Time since injury	15,6 (8,3-30,0)

Values express absolute, relative or average frequency ± standard deviation or (percentile25-percentile75)

Comparing pre- and post-intervention attention and functional independence, statistically significant results were observed, as described in Table 2.

Table 2. Pre- and post-intervention functional independence and attention

	Pre-intervention	Post-intervention	P
MIF	102,3±23,4	107±18,6	0,044*
Trails form 1	187,5±78,2	200±111,3	0,445
Trails form 2	330,5±140,8	259,4±112,5	0,039*
Trails Interference	0,8±0,5	0,4±0,3	0,036*

Values express average ± standard deviation
Trails Test Forms 1 and 2 Unit: seconds

Regarding the functional independence evaluated by the FIM test, the total result evidenced statistically significant differences following intervention with the video game. In pre-intervention, the score was 102.3 ± 23.4, indicating modified or assisted dependence, i.e., the need of another person for supervision or physical help to perform the activity; and in post-intervention, the score was 107 ± 18.6, indicating modified independence, in which the activity requires technical help, adaptation, braces, high execution time or cannot be executed with complete safety[15].

Another important point observed was related to attention (Trails Test – Form 2) and interference. We identified an improvement of the divided attention of the older adults, since the test execution time was reduced from 330.5 ± 140.8 to 259.4 ± 112.5 seconds, and interference by the professional psychologist also fell, from 0.8 ± 0.5 to 0.4 ± 0.3.

DISCUSSION

In the Colored Trails Test, differences were noted following administration in Form 2, which evaluates divided attention. Although this phase of the test is more complex and demands greater attention to be executed, the older adults showed significant differences. We believe that because the video game required the older adults to be attentive to objects appearing on the screen and at the same time perform body movements, this stimulated divided attention.

On the other hand, sustained attention showed no significant results. This is supposedly related to the fact that the game required the execution of two tasks, i.e., observing the stimulus and performing the movement at the same time. Unlike *Motion Rehab*, researchers of the *NeuroRacer* study identified that training resulted in a higher frequency of theta waves in the brain of older adults. This alteration revealed that the group of older adults had a significant gain in sustained attention and also in short-term memory, with results persisting up to six months after training was over[6].

The hypothesis of gain in cognitive performance through the use of video games is based on the notion that subjects will be immersed in a challenging environment over an extended period of time, needing constant visual and visual-spatial information, hearing attention, visual and spatial processing, mental rotation, sensitivity to contrast, cognitive flexibility, working memory, and reduced information processing time[6,7].

The results of the intervention of the *Motion Rehab* video game on attention and functional independence corroborate those of Kim el al.[10], in which 28 older adults were divided into Control Group and Experimental Group. The EG received virtual environment training with four different programs and computer-based cognitive rehabilitation, while de CG received computer-based cognitive rehabilitation. The authors identified improvement in attention and activities of daily living (ADL). As in *Motion Rehab*, the difficulty level was controlled by adjusting the speed and distance to objects according to patients' physical condition. It should be noted that in Kim el al.[10], patients also continued with their conventional physical therapy treatment. In addition, in the evidence-based study by Pompeu et al.[11], benefits were also observed in the rehabilitation of CVA patients using virtual environments in gait, balance, motor controls, cognition, and perception.

The findings of the research developed with the use of the *Motion Rehab* game identified in the initial FIM evaluation a score corresponding to the situation of dependence of older adults with CVA sequela. These results corroborate the findings of Cruz et al. [19], in which the total average was 97.0 (± 22.3), agreeing with the same dependence aspect. The authors further identified that older adults with CVA sequela usually present significant changes in functional capacity, directly affecting the issue of independence.

According to Parayba and Veras[20], a factor that has been considered positive to reduce the effects of functional decline or dependence is the association of medical treatment with the use of technology. By using the *Motion Rehab* game, it was possible to observe the transition from dependence to functional independence, allowing older adults to execute specific tasks with less interference from third parties.

Furthermore, one of the recurrent concerns of physical therapists working with cognitive and motor rehabilitation has been patients' adherence to treatment, mostly on a long-term basis. The study developed with the use of a video game relates to the perspective of designing new approaches to diversify treatment, making it more attractive and efficient with the use of computer resources[21].

The results of the video game-based intervention in older adults with CVA sequela confirms, alongside the other studies, that it was possible to contribute to the motor and cognitive evolution of participants demonstrated in the Trails Test Form 2 (divided attention) and the Functional Independence Test (FIM).

CONCLUSION

With the research concluded, it was possible to ascertain that interventions with video games can be used safely and efficiently in post-CVA rehabilitation. The results obtained strengthen the hypothesis that the *Motion Rehab* game has proven to be an additional form of efficient rehabilitation.

However, it is still necessary to evaluate the use of the *Motion Rehab* game with a larger number of older adults suffering from CVA sequela. A suggestion for future studies is implementing the protocol only among patients of hemorrhagic CVA, since those with ischemic CVA were prevalent in this study.

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