Use of videogames for functional rehabilitation dynamic for upper limbs in older adults, advanced age and elderly

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Abstract— **This work proposes an alternative for functional rehabilitation in older adults, they are losing their skills motors as psychological cause their age, so in this paper videogame-based systems were designed for functional rehabilitation for upper limbs in older adults. The systems have hardware y software, where software was designed in C language and the Unity for Android platform. The aim of this work is give rise to older adults play with funny videogames while they are working with upper limbs as functional rehabilitation through the execution of pronosupination and flexo extension exercises. 55 people participated in the tests (49 without Neurodegenerative Diseases ND and 6 with Parkinson's Disease PD), so Chi-square goodness of fit test about improvement of rehabilitation was made between older adults, advanced age and elderly for ND and PD, where the results showed that the recovery progression is the same to people without ND and people with PD.**

Keywords—videogames, tablet, Unity platform, functional rehabilitation, neurodegenerative disease, Parkinson's disease.

I. INTRODUCTION

In the nowadays, the older people between 50 and 80 years old [1], have the most probability to get illness than younger people furthermore their recovery is more slowly and incompletely. Geriatric physiotherapy is the application of certain physiotherapy techniques on healthy older adults, in which the involute process of aging can trigger many pathological processes that can lead to decrease of their functional capacities. The most common cause of loss of functional abilities in the older adult is inactivity or immobility [2]. The aging effect over the locomotor system can cause disturbs on the normal activities about daily life, so the older people must be to use the technical aids as cane, crutches, walker and glasses to recovery their autonomy and independence. These technical aids can solve numerous problems due to joint mobility deficit, lack of strength, coordination and visual disturbances. To keep older people more active, specialists suggest that they must go to rehabilitation program that helps them improve their motor skills, concentration and physical activity.

Rehabilitation through physical exercises contributes to one of the most important factors to improve the level of life of older adults like as is the ability to move by themselves. Rehabilitation either in specialized centers or using more current techniques and technology, such as the use of video games designed for these people specifically. It has been discovered that thanks to video games these people perform their rehabilitation with more enjoyment and better mood, compared to conventional therapy which is usually a long and tedious process, and in many cases the sick or not follow the instructions of the therapists, or get tired of repeating the same movements [2]. Videogames unlike most therapists, can motivate the patient to perform physical activities and enjoy doing so. For the brain to stay young it is necessary to exercise it being one of the best options to do it using videogames according to a study presented by [3,4]. In this study, it was concluded that the use of video games really improves mental and motor skills in people.

Nowadays video games in the elderly are not only an option for fun leisure, but it is also beneficial to keep in shape some physical and cognitive abilities. Several investigations have shown among other benefits that videogames in older adults can show satisfactory results as a tool to help in the treatment of depression, to increase visual capacity, or to increase their motor skills.

The objective of this work is to develop two mini video games of therapeutic help or for rehabilitation for the elderly, specialized games to improving their motor activity in the upper limbs added the fact its provides entertainment. The software was developed on the Android platform because the system can be implemented by smartphones or tablets, since everybody, young or old people, have access to this kind of electronic.

II. TABLETS VS SMARTPHONES

Tablets are electronic devices used by people of all ages, these devices are used for entertainment, productivity and a multitude of uses. And it knows that it is a great advantage is the size and portability offered in nowadays, and many kinds of software that you can choose between iOS (iPad), with Android or with Windows 8.

The tablets integrate processors that consume less energy, although they incorporate less memory. Some models available in the market include micro SD slot, thus increasing the storage possibilities [5,6]. The users that more access to these technologies are the elderly people. It was due to the portability and duration of the battery, since it is a device that offers all in one, with a screen resolution which is better for adults, due to the visual limitation in older people. These electronic devices offer more confidence in their use for older people [7].
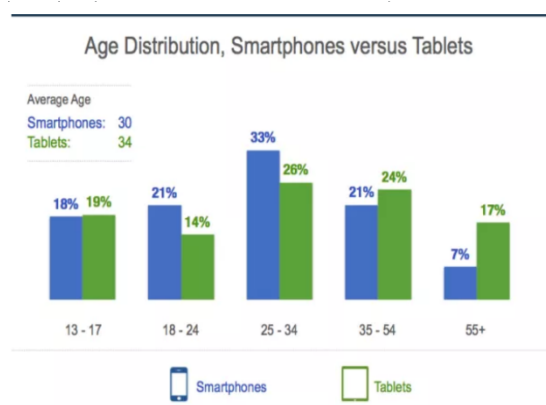
Fig. 1. Percentage of acquisition of a tablet vs Smartphone by age range [5]

The Fig. 1 shows the preferences about to use tablet or smartphone by age range. It can see that almost 3/4 of smartphone users are under 34 years old. While 2/3 of tablet owners are older than 25, and the group with more difference between smartphones and tablets are the people in range between 55 or more.

The use given to these devices is varied, but emphasis is placed on entertainment, in Fig. 2 we can see that entertainment is almost exclusively for tablets, and the most applications of the tablets is to play videogames.
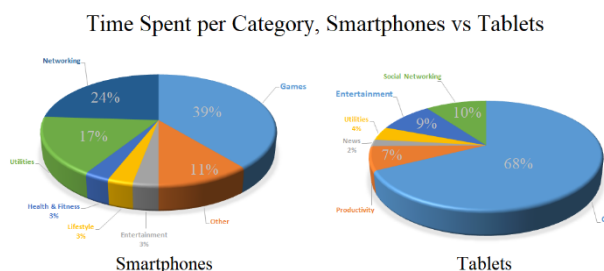

Fig. 2. Categorization of use of Smartphone vs Tablets [5].

III. METODOLOGY

A. Exergames

a) PlaneGame: consisting of three levels (three scenarios), the objective of the game is to transport a plane avoiding obstacles, as the plane collides with the obstacles decreases the energy level until losing the game completely. During the game two arrows appear: an arrow indicates the final goal changing color and another arrow that moves along with the plane to point to the targets (Fig. 3*)*.

As the level is advanced, the number of targets to reach increase and the speed of the aircraft's travel also. The objectives are geometric figures: rings, triangles and squares. Also stimulating elements such as: relaxing music, stimulating environments, incentive rewards.
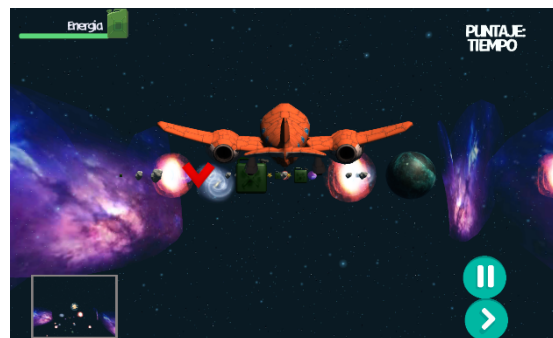

Fig. 3. Third Level of the PlaneGame mini game in Unity.

b) BallGame: Composed of two scenarios: level 1 is a path that is around lava and the goal is to reach the volcano, while level 2 contains a path with water around and the goal is to reach the mountains (Fig. 4).

In each scenario players have to move a sphere up and down. The movement of translation is forward, with the aim of reaching the geometric figures placed on the path without colliding with the variations of the road and obstacles.
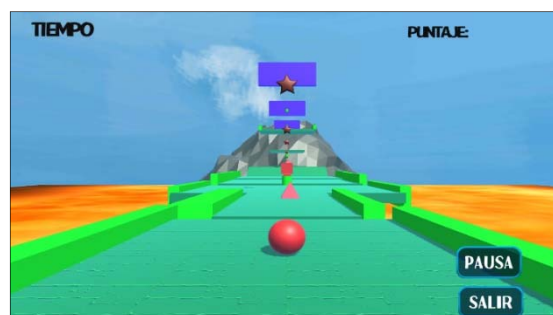

Fig. 4. First Level of the BallGame in Unity.

B. Patients

For the study and validation of the developed videogame, 55 people participated, between men and women, in an age range of 39 to 89 years, of which 49 are people without diagnosed Neurodegenerative Diseases (ND) and 6 have Parkinson's Disease (PD). The classification of patients is indicated in Table I, it should be mentioned that patients with PE were medicated during the tests (ON state).

TABLE I. CHARACTERISTICS OF THE PATIENTS WHO PARTICIPATED IN THE TESTS

		Number of patients	
	Age	*Without ND*	*With PD*
Older adults	39-59	6	0
Advanced age	60-74	34	3
Elderly	75-89	9	3
Total		55	

C. Test parameters

Each participant was placed in a chair at a distance of 30cm with respect to the position of the Tablet and then proceeded to play the two video games developed, respecting the instructions described, which include the movements of pronosupination and flexo extension.

The duration of practice for each video game was 2 minutes per level, if the patient performs the two video games (a total of 5 levels), gives a total of 10 minutes of testing. The control device is alternated between the left and right hand.

There were five sessions of play for the right hand and five sessions for the left hand, with a duration of 8 minutes in each hand, at the end of the game the score and time values of each patient were obtained.

D. Statistical calculations

Participants without PD were divided into three groups: mature adults, Advanced age and elderly. Time data and scores achieved were stored in the device memory of each session performed. Then, the data was processed with the Excel digital calculation tool, which was calculated for each group and for each day:

- The score per unit of time (pints/time).
- The arithmetic mean [8].
- The maximum and minimum values.

Square Chi was used to compare the scores of patients with PD and without diagnosed ND for both video games. The hypothesis null was: *The progression of rehabilitation of patients with PD has the same distribution and trend as patients ND* [9].

IV. RESULTS

The daily results of each group were plotted and compared with the data of the patients with PD in order to verify if the trend of progress of the motor rehabilitation of PD is the same as patients without ND.

A. Piane Game

Following the instructions of the game, the patients participated in PlaneGame mini-game and the results were recorded for ten days (2 continuous weeks from monday to friday). In Fig. 5 illustrated the progress of rehabilitation of the three groups of the Third Age with the game.
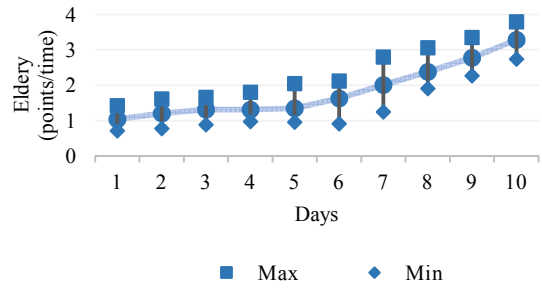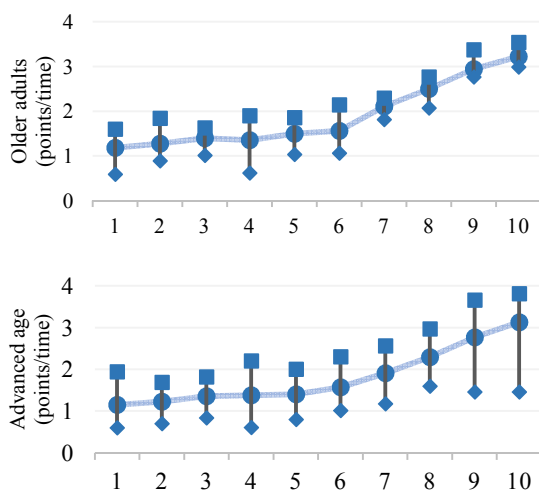

Fig. 5. Motor rehabilitation of minigame PlaneGame in: older adults, advanced age and elderly.

The averages of the outcomes of the PD patients were compared with the overall average of the non-PD patients, as shown in Fig. 6.
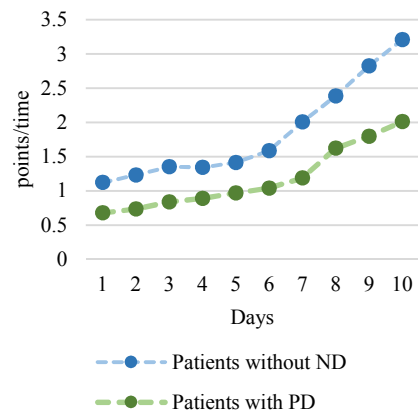

Fig. 6. Motor rehabilitation of patients with PD and patients without ND with PlaneGame mini-game.

Using Chi Square (χ^2) math tool, based on the null hypothesis mentioned above and the data in Fig. 6, the results shown in Table II.

TABLE II. CHI-SQUARE TEST APPLIED TO PLANEGAME MINI-GAME RESULTS.

Days	fe	fo	χ^2
1	1.12	0.68	0.17
2	1.23	0.74	0.19
3	1.35	0.83	0.19
4	1.34	0.89	0.15
5	1.41	0.97	0.13
6	1.58	1.04	0.18
7	2.01	1.19	0.33
8	2.39	1.62	0.24
9	2.83	1.79	0.37
10	3.21	2.01	0.44
χ^2 Calculated			**2.45**

From the above table the degrees of freedom (9) are obtained and a confidence level (99%) is assigned. Based on the degrees of freedom and the level of confidence, a value of χ^2 critical equal to 21.66, according to the table of [10].

Considering that: $\chi^2_{calculated}=2.45< \chi^2_{critical}=21.66$, the null hypothesis is declared valid.

B. BallGame

For the BallGame game results were collected for 5 consecutive days (1 week from monday to friday), we distributed and graphed the results in the same way as in the PlaneGame mini-game, in Fig. 7 the measurements are shown.
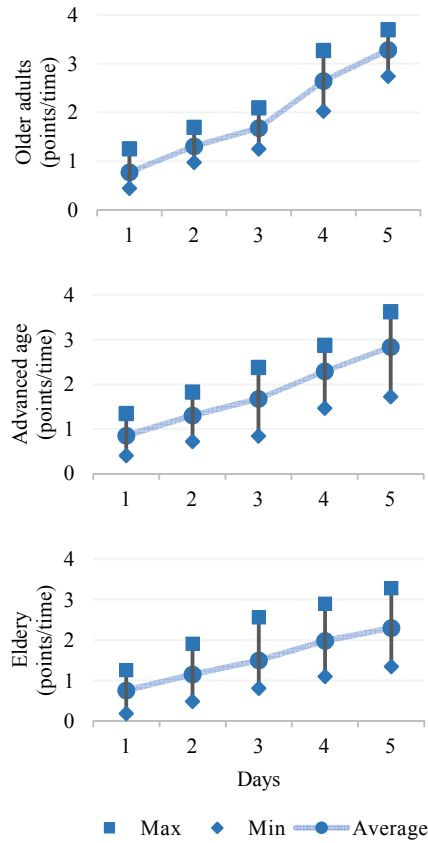

Fig. 7. Motor rehabilitation of BallGame mini-game in: older adults, advanced age and elderly.

Averages of the results of patients with PD were compared with the total mean of patients without ND, as shown in Fig. 8.
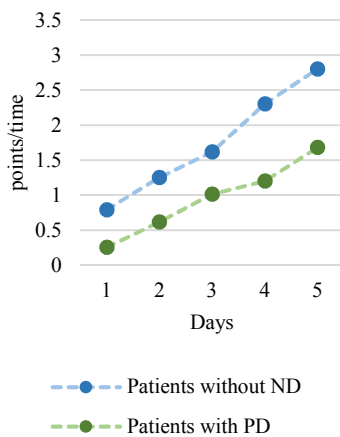

Fig. 8. Motor rehabilitation of patients with PD and patients without ND with BallGame mini-game.

As with the PlaneGame game, the $\chi2$ is calculated according to the null hypothesis of the methodology and the data of Fig. 8, the calculation parameters are presented in Table III.

TABLE III. CHI-SQUARE TEST APPLIED TO BALLGAME MINI-GAME RESULTS.

Days	fe	fo	x2
1	0.79	0.26	0.36
2	1.25	0.62	0.32
3	1.62	1.01	0.23
4	2.31	1.20	0.53
5	2.80	1.68	0.45
χ2 Calculated			1.89

The degrees of freedom according to Table III are 4 and assigned the confidence level imposed is 99%. According to the degrees of freedom and the level of confidence, a critical χ^2 value equal to 13.28 is achieved, according to the table of [10]. Since that: $\chi^2_{calculated}=1.89< \chi^2_{critical}=13.28$, the null hypothesis is assumed to be valid for the BallGame game.

V. ANALYSIS OF RESULTS

In this section we present a comparison using an Axus Tablet in relation to the data obtained with a Samsung Smartphone, in Fig. 9 shows the comparison in patients with PD and patients without ND (non-PD) of the Tablet and the Smartphone, with the purpose of knowing if there is a difference in the results when using different mobile devices.
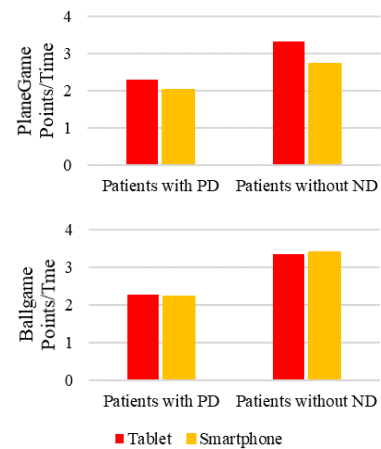

Fig. 9. Results of using the Tablet and Smartphone during exergames.

According to Fig. 9, the use of the Tablet during the execution of the PlaneGame game allows reaching at least 14% improvement (in Patients with PD) with respect to the Smartphone; whereas the use of the Tablet for the BallGame game reflects improvement in patients with PD (2.25%) and not in the group of patients without ND (-1.79%). The increase in the points/time ratio demonstrated by the use of the Tablet could be an indicator that this device has a higher degree of acceptance in the elderly population, as well as evidence of accelerating the process of motor rehabilitation of the upper limbs.

To compare the effect of performing therapies with exergames developed against conventional therapy, a motor

test was performed for two minutes in each arm, which consists of the patient catching the largest number of pompoms with the indicated color and placing them inside an attached container. For the process there were 15 patients (10 without ND and 5 with PD), all the participants who had undergone conventional therapy performed the motor test, in which the number of pompoms trapped and placed correctly was registered, after having completed the rehabilitation therapy with the PlaneGame and BallGame games, proceeded again to try the same motor test, the results are shown in Fig. 10.
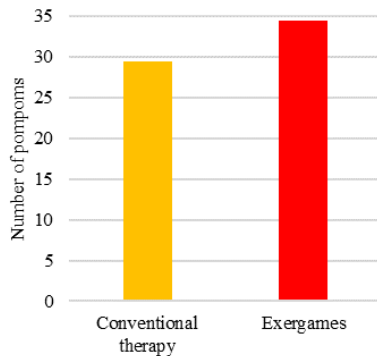

Fig. 10. Comparison of motor skills between conventional therapy and exergames.

The participants reached an average of 29.39 pompoms, while after undergoing videogame-based therapy they obtained an average of 34.38 pompoms (16% improvement). The results show that therapy using exergames is more effective than conventional therapy in motor rehabilitation of the upper limbs.

VI. CONCLUSIONS

Two mini virtual games were developed with therapy parameters focused on motor rehabilitation of the upper extremities of older adults. It was found that the therapies based on exergames are of continuous progression in terms of rehabilitation inside of three groups of older adults (older adults, advanced age and elderly).

The mini game named PlaneGame presented better results in points/time assessment compared to BallGame, this may be since the PlaneGame game contains a more stimulating environment design for the elderly.

The data of the participants with the PD showed progression during the rehabilitation and that they have the same distribution and tendency as the patients without ND, the comparative between results in differents ages, with PD and without ND was realized with the Chi square test.

The comparison of exergame therapy using Tablets presented better results with respect to the use of the Smartphone, in addition a body motor test showed that exergames improve activity in the upper limbs compared to conventional therapy.

Exercises based on videogames and technological devices were considered as the best option for motor therapy, in addition to the fact its provides fun during rehabilitation and allows the improvement of body movements in general.

The advantages of to use videogames compared to conventional therapy are: reduction of personnel, improve their stimulation, reduction of costs and increased interest of the participants towards their recovery.

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