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# Contrasting performance between physically active and sedentary older people playing exergames

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**Abstract**

The increase in life expectancy associated with the increase in chronological age and less active people helps in the appearance of chronic and degenerative diseases. The encouragement of physical exercises contributes to older people abandoning sedentarism and preventing such diseases. Exergame is a promising alternative, for making exercise a pleasurable activity.

In this study, we compared the performance of physically active older people with sedentary older people in exergames.

Participants were 83 older adults over 65 years of age, of both sexes, divided into 2 physically active older people (AG) and sedentary older people (CG) groups. The participants performed a task through an exergame called "MoviLetrando" that uses the score, number of hits, number of omissions, and an average time of hits as an evaluation. A characterization questionnaire was applied, with information about sex, age, marital status, economic class, self-rated health, time of use of electronic games, a questionnaire on the practice of physical activity, and the Brunel Mood Scale.

There was a higher exergame score in AG than in CG ($P=.003$), in the number of correct answers ($P=.012$). The number of omissions was lower in AG than in CG ($P=.023$). The mean time of correct answers was lower in AG than in CG ($P=.013$). The regression analysis revealed a significant finding $F(3, 82)=11.06$, $P<.001$ and showed a prediction ability of 26.9% ($r^2=.269$). Three variables remained significantly associated with the score: physical activity was marginally significant ($\beta=.19$, $P=.06$), age ($\beta=-.403$, $P<.001$), depression ($\beta=-.212$, $P=.028$).

Physically active older people perform better when compared with the sedentary older people. Age, depression, and physical activity influence the performance in exergame.

**Abbreviations:** AG = physically active older people, BMI = body mass index, BRUMS = Brunel Mood Scale, CG = sedentary older people, EG = Exergames, ICF = Informed Consent Form, IPAQ = International Physical Activity Questionnaire, MMSE = Mini-Mental State Examination, RFD = Rapid Force Capacity, short FES-I = Falls Efficacy Scale – International, SPSS = Statistical Package for Social Research, TUG = Timed Up & Go, UDESC = Universidade do Estado de Santa Catarina, VR = Virtual Reality, WHO = World Health Organization.

**Keywords:** aged, information technology, software, video games

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## 1. Introduction

Data from the World Health Organization (WHO) show that the population over 65 in 2010 was 524 million and could reach 1.5 billion by 2025[1]; in the face of this panorama, much has been discussed about the conditions of life and chronic diseases in the older people.

According to Faria et al,[2] as chronological age increases, people become less active, which facilitates the appearance of chronic and degenerative diseases. And to try to minimize or even slow this process, physical activity has been indicated as a fundamental part of the global health promotion programs.

The aging process is associated with physical, physiological, psychological, and social changes and also with the appearance of chronic-degenerative diseases due to inadequate living habits (incorrect feeding, the absence of regular physical activity, and smoking), reflecting the reduction of activities.[3] The loss of muscle mass and consequently muscular strength is one of the main processes verified in aging, affecting mobility and functional capacity directly, which implies the loss of the autonomy of older people.[4] The aging process is common to all, but the rate at which this decline occurs varies not only from one organ to another but also from one older individual to another even having the same chronological age.[5]

According to Santos and Knijnik,[6] physically active seniors can be between 10 and 20 years younger than physically inactive older people when it comes to biological age. In recent years, there has been a growing interest in studies that relate regular, systematic physical activity to a healthy aging process, mainly regarding its impact on the quality of life of older people.[7]

The number of products and services aimed at this population, including the development of games aimed at health promotion, takes into account the physical and social difficulties they face.[8] According to Azuma,[9] Virtual Reality (VR) is a technology that combines the user's "vision" with the real world with virtual objects projected in real time; in this environment, virtual objects seem to coexist in the same physical space as real objects.[10,11] According to Saposnik et al,[12] this environment makes it possible for users to interact with a 3-dimensional computer-generated scenario during the execution of a given task, allowing for the graduation of the training intensity and providing control of visual, sensorial, and auditory feedback. The advantages of VR include home, online practice, and interaction with other people, as well as the possibility of performing virtual tasks under the supervision of a professional, who can face grading difficulties according to the requirements of individuals.[13]

For older people, it offers the possibility to experience different situations and in an individualized and safe way, as it is possible to transport the elements from the real world to the virtual. In this case, one can eliminate the difficulties and dangers of real environments and interact with technological devices only by using the hands, making the task attractive to the participant.[10] Virtual environments also allow people with some difficulty, when connected or immersed, to improve their levels of interaction with the environment.[14]

Rizzo[15] stated that VR is a "useful tool for the study, evaluation, and rehabilitation of cognitive processes and functional activities" and found that VR's ability to stimulate and store responses offers opportunities for evaluation and clinical rehabilitation that are not available with traditional methods. In VR environments, multisensory channels (vision, hearing, touch, etc) can be amplified and controlled in intensity, time, and space.[11]

Technologies that can serve as tools in the process of inclusion and integration of people are indispensable, and the finding is even more evident when referring to older adults with loss of functionality and locomotion.[16]

According to Bird et al,[17] exergames are exercise-based video games that characterize the player's movement, in which the individual actively participates in the game, combining fun, ability, and intensity. Also, Van Diest et al[18] have identified exergames as promising training for healthy older adults. Because it is a game, attention is focused on the results of the movements, making exercises a pleasurable activity.

Given the considerations presented, the use of games in VR seems to be an effective tool in stimulating physical activity in the older people, favoring activities in the family, leading to activities within the homes of each one.

Thus, the objective of the present study is to compare the performance of physically active older people and sedentary older people in exergames.

## 2. Method

### 2.1. Research participants

A cross-sectional[19] study was carried out at the General Ambulatory of the ABC School of Medicine, from October 2016 to April 2017. The study included 83 older subjects over 65 years of age, of both sexes under a convenience sample. They were divided into 2 groups: physically active older people (AG) and sedentary older people (CG). All volunteers were informed about the procedures and objectives of the study, and after agreeing, a signed informed written consent was obtained from each volunteer.

### 2.2. Inclusion criteria

Participants signed the informed consent form (ICF) before the start of data collection. The participant was included in the research when he was able to understand the indications regarding the task proposed in the game and was able to perform the necessary movement without presenting a symptom of pain or discomfort during the execution of the task. After the verbal demonstration, only 1 participant did not feel able to perform the movements, and so the patient was excluded from the research.

For the nonsedentary older people group, participants had to be considered active and/or very active by the IPAQ (International Physical Activity Questionnaire).

For the sedentary older people group, participants had to be considered sedentary by IPAQ.

### 2.3. Exclusion criteria

Older individuals with upper limb impairment that prevented the achievement of the proposed task and with a cognitive deficit that impaired performance in the research were excluded.

### 2.4. Procedures

Data collection was carried out in a private environment with the presence of only the researcher. Participants were accommodated comfortably in a height-adjusted chair.

After signing the ICF, the questionnaire for the characterization and application of the Brunel Mood Scale (BRUMS) was requested.[20]

The task was demonstrated verbally by the researcher.

### 2.5. Tools

The proposed task is a serious game developed by the LARVA group[2] from the Universidade do Estado de Santa Catarina (UDESC) that is available for use.

**2.5.1. Moving.** MoviLetrando uses the game concept with VR Projection and without the need for an interaction device (motion sensor) to facilitate usability.[21] To play MoviLetrando, you need a computer or notebook with a webcam.

The VR projection or VR video capture creates mirrored images so that users can see themselves on screen. This is different from traditional VR environments, which use motion sensors (Kinect, Nintendo Wii) or data gloves, not requiring the use of portable sensors or other additional devices that are used to stimulate the virtual environment, thus granting more freedom. Users can interact directly with objects without the use of virtual characters (avatars) on the screen. Therefore, the VR projection offers a more intuitive interaction, which allows users to experience their body's natural heads, hands, or body movements when interacting with objects on the screen.[22]

The game scenario is the image captured by the camera with the player inserted in the scene itself (Fig. 1). This aspect helps to develop proprioception, which is the ability of the individual to know one's own body and define the motor strategies needed to execute a given movement.

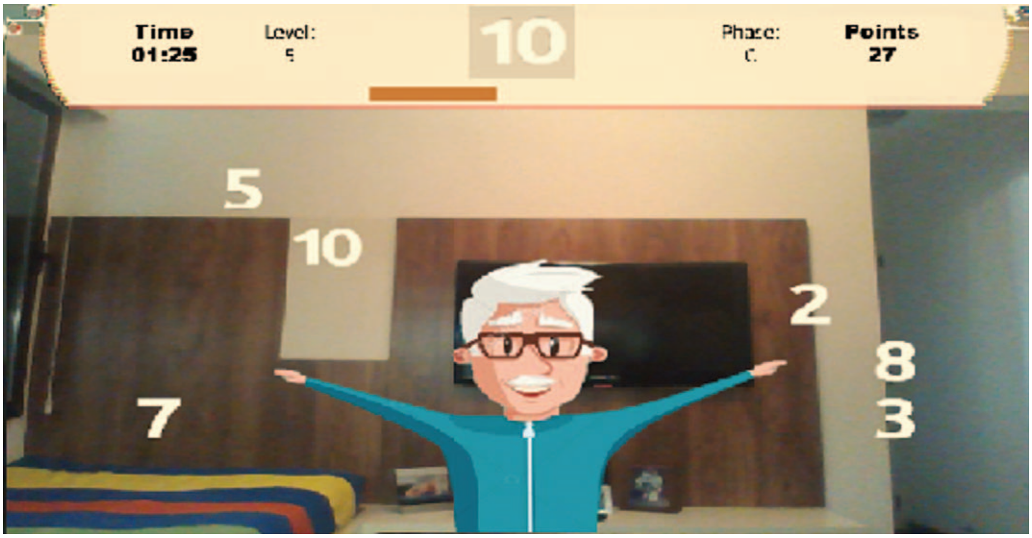


**Figure 1.** MoviLetrando game interaction screen.

The score on the MoviLetrando is given by the hits of the captured symbols and the time of exposure of the symbols. The faster the participant touches the requested symbol, the greater the number of symbols will be displayed, making it possible to achieve a higher score. The game works with the concept of levels and phases that evolve according to the performance of the players. Symbols consist of numbers, vowels, consonants, and numeric sets, which can be defined individually or in combination. The stimulus used to present the symbols can be visual, sound, or both. Also, it is possible to set the size and number of symbols displayed, the time available to capture them, and the side displayed on the screen (right, left, or both), always according to the phase and level selected.

The player must assemble strategies to get the correct symbol and can do this with any limb of the body, but usually using their hands.

We standardized phase C and level 5 by presenting 6 numbers, for 8 seconds, distributed between the 2 sides of the participant as shown in Fig. 1.

They were run on notebook PCs with an Intel Core i7-4810MQ CPU 2.80 GHz processor, 8GB of RAM, a webcam with 30FPS, and a Windows 8 Professional 64-bit operating system.

***2.5.2. Questionnaires.*** An evaluation questionnaire with socio-demographic information was applied, regarding sex, age, marital status, economic class, health self-evaluation, time of use of electronic games, besides the questionnaire of physical practice and state of humor.

All questionnaires were applied at the beginning of data collection, just before the exergames.

***2.5.3. International physical activity questionnaire (IPAQ).*** The level of physical activity was assessed by the IPAQ short version. The trial was validated in 2003 by Benedetti et al[23] with older women, with excellent test–retest reproducibility. The short version is a 7-item instrument with the specification of a series of class activities held in a typical week, including activities performed at work. The individual can be classified as sedentary, insufficiently active, active, and very active.[24]

The individuals classified as active and/or very active by the instrument were allocated to the physically active group (GA), and the sedentary individuals in the control group (CG).

***2.5.4. Brunel mood scale (BRUMS).*** Mood states are a set of subjective feelings that involve more than 1 emotion, of an ephemeral nature and that vary in intensity and duration, reflecting nonspecific changes. Their constructs are composed of 5 negative factors (tension, mood depression, anger, fatigue, and mental confusion) and a positive one (vigor).[25]

The Brunel Mood Scale validated in Brazil by Rohlfs et al[20] has shown to be a sensitive instrument in studies with athletes[26] and patients of cardiopulmonary and metabolic rehabilitation programs[27]. The evaluation of the mood states of the participants of this research can contribute to the evaluation of their performance.

BRUMS has 24 items arranged in 6 subscales (anger, confusion, depression, fatigue, tension, and vigor), each with 4 items. The participant should select a numerical rating scale from 0 to 4 (0 = nothing, 1 = a little, 2 = moderately, 3 = quite, 4 = extremely), for the option that judges to be the one that best represents his situation in the question "How do you feel now? ". The Items of each subscale are Anger, Confusion, Depression, Fatigue, Tension, and Stamina.[20,26]

### 2.6. Ethical aspects

The Research Ethics Committee of the *Faculdade de Medicina do ABC* evaluated the protocol for this research, approving it on September 28, 2016, under ruling 1,752,095, since the protocol met the requirements of Resolution 466/12, the Nacional Health Council/Ministry of Health, which deals with research involving human beings.

### 2.7. Statistical analysis

We used the Excel 2013 programs for the construction of the database and the SPSS software (Statistical Package for Social Research) version 21.0 for statistical analysis. The Kolmogorov–Smirnov test was used to verify the normality of the data.

Descriptive statistics were done using standard deviation or median and their percentiles. For the quantitative variables, the Mann–Whitney test was used, for the others the Chi-square test. A significance level of .05 ($P<.05$) was defined for this study, with 95% confidence intervals.

A linear regression analysis was performed in the reverse mode to verify which factors influenced the score of the game. The variables gender, age, physical activity (AG and CG), body mass index (BMI), mood profile (BRUMS), schooling, marital status, and use of electronic games were included in the initial model; after adjustments, the final model was generated with the variables associated with the score of the game.

## 3. Results

The 83 patients involved in this study had a mean age of 72±7 years, of whom 75% were female.

Table 1 summarizes the descriptive data of the sample characteristics and the mood profile (BRUMS). When groups were compared, significant differences were found in age ($P=.02$) and sex ($P=.01$).

The median score shows an increase of 52 points with the 25th percentile of 31.25 points and 75th percentile of 60.5 points for 64 points with the 25th percentile of 49.50 points and 75th percentile of 78 points between the CG and AG groups with a statistically significant difference ($P=.003$) (Fig. 2).

There was an increase in the median number of hits of 6 hits with the 25th percentile of 4 hits and 75th percentile of 8.25 hits for 8 hits with the 25th percentile of 6 hits and 75th percentile of 10 hits between CG and AG groups with a significant statistical difference, $P=.01$ (Fig. 2).

The median number of errors remained stable with 4 errors in both groups, with the only percentile changes being 3 errors in the 25th percentile and 6.25 errors in the 75th percentile in the CG group and 2 errors in the 25th percentile and 6 errors in the 75th percentile. Thus, there was no statistical difference between the groups, $P=.24$ (Fig. 2).

The number of omissions showed a drop in the median and the 25th percentile, with 1 omission and the 75th percentile being 3 omissions for a median and the 25th percentile of 0 omissions and the 75th percentile with 2 omissions in CG and AG groups with a statistically significant difference between groups, $P=.02$ (Fig. 2).

There was a decrease in median, mean touch time of 6.54 seconds with the 25th percentile of 6 seconds, and 75th percentile of 7.04 seconds for a median of 6.07 seconds and 25th percentile of 5.59 seconds and 75th percentile of 6.55 seconds between CG and AG with a marginal statistical difference, $P=.059$ (Fig. 3).

The median shows a decrease in the meantime of hits of 6.7 seconds with the 25th percentile of 6.18 seconds and 75th percentile of 7.51 seconds for a median of 6.14 seconds and 25th percentile of 5.55 seconds and 75th percentile of 6.66 seconds between CG and AG groups with a statistical difference between groups, $P=.01$ (Fig. 3).

The mean error time showed a small decrease in the median of 6 seconds with 25th percentile of 5.74 seconds and 75th percentile of 7.04 seconds for median 5.87 seconds with the 25th percentile of 5.33 seconds and 75th percentile with 6.46 seconds for CG and AG groups without statistically significant difference between the groups, $P=.20$ (Fig. 3).

Regression analysis (Table 2) revealed a significant finding $F(3, 82)=11.06$, $P<.001$ and presented predictive prediction ability of 26.9% ($r^2=.269$). Three variables remained significantly associated with the score: physical activity was marginally significant ($\beta=.19$, $P=.06$), age ($\beta=-.403$, $P<.001$), depression ($\beta=-.212$, $P=.03$); these variables were automatically selected by the SPSS (Statistical Package for Social Research) version 21.0.

**Table 1**

**Characterization of the sample.**

| Variables | AG (41) | CG (42) | P* |
|---|---|---|---|
| Age, y | 69.37±5.56 | 74.17±8.6 | .02 |
| Total body mass, kg | 71.49±12.96 | 69.74±13.65 | .51 |
| Height, m | 1.59±0.07 | 1.62±0.08 | .08 |
| BMI, kg/m$^2$ | 28.28±4.46 | 26.5±3.76 | .12 |
| BRUMS | | | |
| DTH | −6.34±11.65 | −5.45±9.65 | 1.00 |
| Hostility rage | 2.2±2.03 | 2.33±2.06 | .75 |
| Mental confusion | 2.68±2.59 | 2.33±2.48 | .56 |
| Depression | 2.37±2.77 | 2.43±2.73 | .80 |
| Fatigue | 3.63±3.06 | 3.4±2.62 | .96 |
| Anxiety-strain | 5.12±3.47 | 4.07±2.87 | .20 |
| Stamina | 9.66±2.4 | 9.12±2.68 | .42 |
| Gender (%) | | | |
| Female | 88 | 62 | .01† |
| Male | 12 | 38 | |
| Schooling (%) | | | |
| Illiterate | 5 | 5 | .29 |
| Fundamental I | 22 | 40 | |
| Fundamental II | 12 | 12 | |
| High School | 41 | 21 | |
| University | 20 | 21 | |
| Marital status (%) | | | |
| Married | 61 | 50 | .86 |
| Divorced | 10 | 10 | |
| Separated | 2 | 5 | |
| Single | 5 | 7 | |
| Widowed | 22 | 29 | |
| (% Uses electronic games) | 83 | 88 | .50 |
| (%) Does not use electronic games | 17 | 12 | |

* Mann–Whitney test for quantitative variables and Chi-square test for qualitative variables.
† Bonferroni post-test detected predominance of females in both active and sedentary groups; *P* value/ level of significance (*P*); Physically active elderly (AG); Sedentary elderly (CG); Brunel mood scale (BRUMS); Total mood disorder (DTH).

## 4. Discussion

The analysis of the results of the number of points, number of correct answers, and an average time of correct answers showed a significant difference between the groups of physically active and sedentary elders. Also, regression analysis showed the influence of age, depression, and physical activity on the score of the game. It is believed that physical exercise demands more attention from older people, which increases cognitive performance, therefore leading to a better performance in exergames.

Sofi et al[28] investigated the association between physical exercise and reduction in cognitive impairment through a meta-analysis. The study showed that individuals who perform with a high, moderate, and even low level of physical activity are protected against cognitive decline. Reinforcing this hypothesis, Dias et al[29] compared the cognitive status of exercising and sedentary elders using the Mini-Mental State Examination (MMSE) and a CogState. The results showed a statistical difference in the MMSE score and better performance in the reaction time and assisted attention among physical exercise practitioners. Likewise, the results of our study show better results in the number of points and correct answers, as well as the

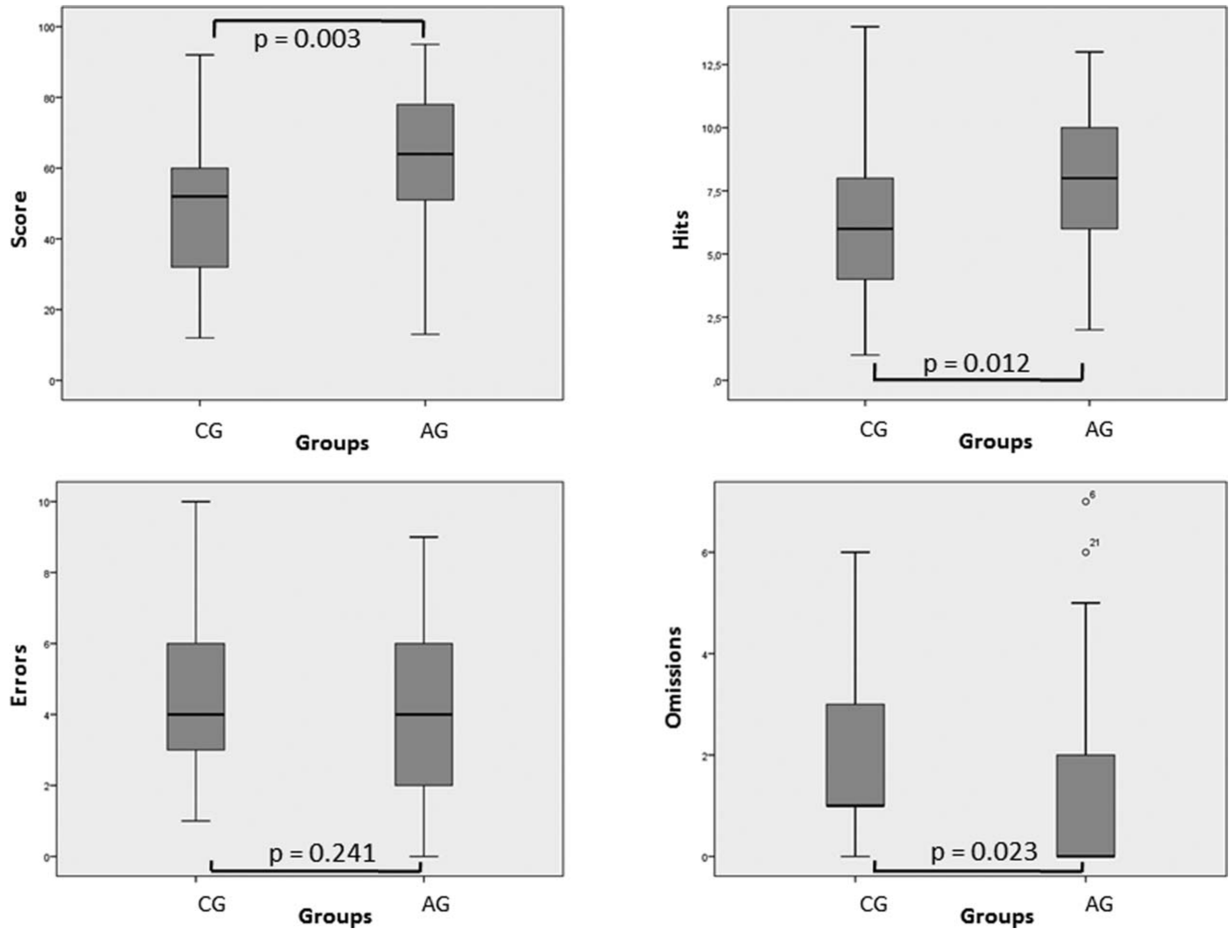


**Figure 2.** Comparison of scores, number of hits, errors, and omissions in the game Movileletrando between the Control and Active groups. Mann–Whitney test; *P* value/level of significance (*P*); Physically active elderly (AG); Sedentary elderly (CG).

average time of correct answers in the physically active older people group.

Following the exergames research related to cognitive functions, Mayas et al[30] promoted a study with 2 groups of older people (experimental and control) to investigate the possibility of neutralizing cognitive decline through video games. The control group did not have access to the games, while the experimental group used the games of a commercial package for brain training. The experimental group presented a reduction in distraction and an increase in alertness, showing that the training allows increasing cognitive performance. From the same point of view, Yasini and Marchand[31] evaluated the use of tablets by older people for 6 months. The evaluation at the end of the sixth month, compared with the evaluation at the end of the first month, showed that game time, success rate, the number of launches, and success rate increased significantly, but the difficulty level did not present changes. The increase in success rates may show improvement in memory and cognitive function, and most participants showed an increase in well-being.

Also related to satisfaction during exergame activity, the study participants of Agmon et al[32] reported improvement in daily activities, pleasure in playing with their grandchildren, and greater dominance with the games at the end of the second month, which can be proved by the increase in the score. Participants in this study reported fun, well-being, and motivation during the game, expressing interest in making further attempts to increase their score.

In addition to being a motivator, exergames can bring physical and social benefits as presented by Karahan et al,[33] who compare interventions with exergames (EG) and exercises at home for 6 weeks, assessing balance, mobility, and quality of life in older people. At the end of the treatment, the EG group stood out, presenting significant results in the tests, reinforced by the comments by the EG group participants, who found the program to be a lot of fun. From the same point of view, Lund and Jessen[34] evaluated the increase in mobility, agility, balance, and general capacity of the older people in training with exergames for 12 weeks. There was an improvement in functional tests such as the Six-Minute Walk Test and Timed Up & Go, showing a relationship between these tests and improvement in health status.

Bird et al[17] showed that older people do not know about the exergames and thus do not enjoy its benefits. The participants answered a survey about their perception of the technology before the interventions and after 5 weeks of interventions using an exergame. There was an increase in the awareness of the use of exergames to improve the state of health, considering the exergames a pleasant resource to assist in the physical activities.

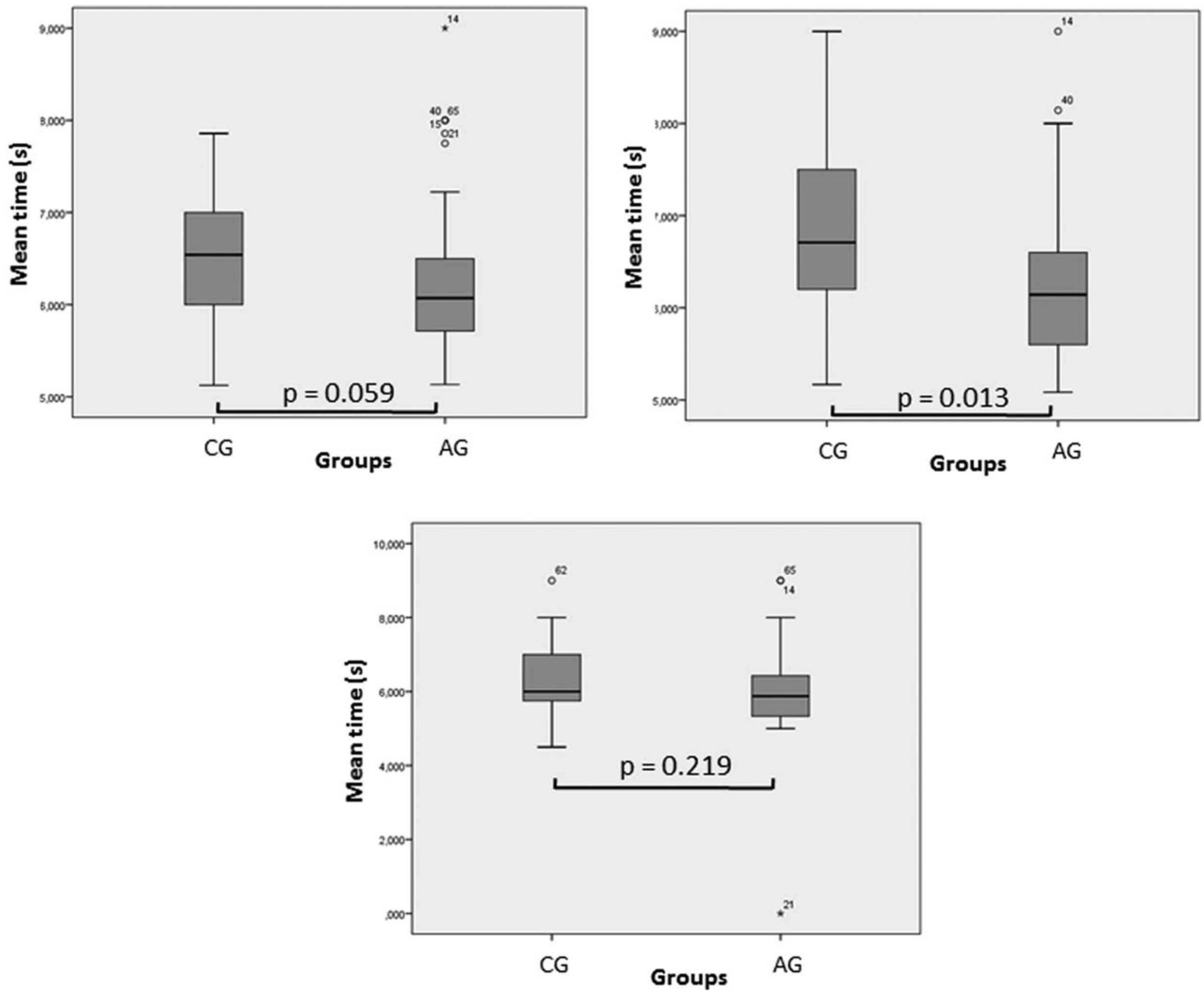


**Figure 3.** Comparison of average touch times, hits, and errors in the game Moviletrando between the Control and Active groups. Mann–Whitney test; *P* -value/level of significance (*P*); Seconds (s); Physically active elderly (AG); Sedentary elderly (CG).

However, our sample had 88% (control group) and 83% (physically active older people group) of older people practicing electronic games on tablets, cell phones, and/or computers.

Jorgensen et al[35] followed 2 groups of older adults, a control group that used insoles and an experimental group that underwent training with Nintendo Wii for 10 weeks. The groups were evaluated before and after the interventions using the rapid force capacity (RFD), Timed Up & Go (TUG), and Falls Efficacy Scale – International (short FES-I). The experimental group showed improvement in functional tests such as FFC, TUG, and short FES-I, and classified the training as highly motivating. In addition to motor functions, Nagano et al[36] performed short- and long-term studies to investigate the effects of exergames on motor functions in older people. They showed improvement in the motor functions and muscular strength of the lower limbs, which indicated prevention of falls. In both cases, exergame proved to be a safe intervention for the older people.

Our study, through regression analysis, showed influence of age ($\beta = -.403$, $P < .001$), depression ($\beta = -.212$, $P = .028$), and physical activity ($\beta = .19$, $P = .06$). In the game score ($F$ (3, 82) = 11.06, $P < .001$), Bittar et al[37] conducted a study with sedentary older women divided into active groups, who underwent a pre-sport games program, and a control group that was instructed

**Table 2**

**Explaining the score in exergame – results of reverse mode multiple linear regression analyses.**

| Variables | β (95% CI) | *P* | $r^2$ |
|---|---|---|---|
| Input model | | | |
| Physical activity | 0.186 (−1.75 to 17.636) | .107 | 0.21 |
| Age | −0.384 (−1.876 to −0.29) | .008 | |
| BMI | −0.132 (−1.746 to 0.397) | .214 | |
| Anger-hostility | −0.066 (−3.144 to 1.741) | .568 | |
| Mental confusion | −0.043 (−2.597 to 1.866) | .745 | |
| Depression | −0.249 (−4.008 to 0.1) | .062 | |
| Fatigue | 0.124 (−1.057 to 2.935) | .351 | |
| Anxiety-strain | 0.007 (−1.766 to 1.866) | .956 | |
| Stamina | −0.087 (−2.708 to 1.249) | .464 | |
| Gender | −0.062 (−14.971 to 8.865) | .611 | |
| Schooling | 0.106 (−2.171 to 5.819) | .365 | |
| Marital status | −0.057 (−3.793 to 2.39) | .652 | |
| Uses electronic games | 0.017 (−11.875 to 13.964) | .872 | |
| Final model | | | |
| Physical activity | 0.19 (−0.357 to 16.543) | .06 | 0.269 |
| Age | −0.403 (−1.694 to −0.577) | <.001 | |
| Depression | −0.212 (−3.133 to −0.186) | .028 | |

CI = confidence interval; $P = P$ value; $r^2$ = Adjusted R square.

not to change their daily routine. Before and after the intervention, the older women answered psychobiological questionnaires to assess the mood profile, cognition, sleep pattern, body image, habitual physical activity level, and quality of life of the volunteers. After 6 months, the active group had lower depression scores.

Rosenberg et al[38] presented a study applying exergames in older people with subsyndromal depression and resulted in a significant improvement in the depressive symptoms and the quality of life related to mental health.

The study showed some limitations such as the sample was not paired by sex, showing a high number of women in both groups with a statistically significant difference between them, and age was also different among the control group (74 years) about the physical activity group (69 years). Also, the tool used as exergame (Movíletrando) does not allow total immersion in the game (virtual environment), making it impossible for more realistic and attractive situations, besides not evaluating parameters such as interactive postural control or body movement registration as in other games.

In conclusion, older people practitioners perform better when compared with sedentary elders. Age, depression, and physical activity influence the performance in exergame.

## Author contributions

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