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Intervention through virtual physical exercise for various capabilities in elderly

Intervenção através de exercício físico virtual para diversas capacidades em pessoas idosas

Intervención mediante ejercicio físico virtual para diversas capacidades en ancianos

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Keywords: Aging; Virtual Reality; Physical Exercise; Psychology.

ABSTRACT

Objective: Compare the evolution of cognitive, physical, and psychological factors among older people, relating the practice of Conventional Physical Exercises with Virtual Reality. Methods: Individuals over 70 years of age of both sexes. Group 1 - Virtual Reality Exercise + Conventional Physical Exercise and Group 2 - Conventional Physical Exercise. The intervention by Virtual Reality Exercise has the virtual stationary gait software Street View, and the intervention by Conventional Physical Exercise has stretching, relaxation and walking activities in 4 months of intervention in 24 participants. Results: We obtained in the Virtual Reality Exercise + Conventional Physical Exercise group improvement in executive function (p=0,001), in relation to technology (0,040), in life satisfaction (p=0.001), in physical capacity (p=0.001), while the quality-of-life variable showed no effect of the intervention (p=0,171). Conclusion: Thus, we show how Virtual Reality intervention helps improve older people's physical functional and psychological performance.

Descritores: Envelhecimento; Realidade Virtual; Exercício Físico; Psicologia.

RESUMO

Objetivo: Comparar a evolução dos fatores cognitivos, físicos e psicológicos em pessoas idosas, relacionando a prática de Exercícios Físicos Convencionais com a Realidade Virtual. Métodos: Indivíduos com mais de 70 anos, de ambos os sexos. Grupo 1 Exercício de Realidade Virtual + Exercício Físico Convencional e Grupo 2 Exercício Físico Convencional. Intervenção por Exercício de Realidade Virtual conta com o software de marcha estacionária virtual Street View e a intervenção por Exercício Físico Convencional conta com a caminhada convencional em 4 meses de intervenção em 24 participantes. Resultados: Obtivemos no grupo Exercício de Realidade Virtual + Exercício Físico Convencional melhora na função executiva (p=0,001), relação à tecnologia (0,040), satisfação com a vida (p=0,001), capacidade física (p=0,001), enquanto a variável qualidade de vida não apresentou efeito da intervenção (p=0,171). Conclusão: Assim, mostramos como a intervenção de Realidade Virtual ajuda a melhorar o desempenho físico, funcional e psicológico de idosos.

Descriptores: Envejecimiento; Realidad Virtual; Ejercicio Físico; Psicología.

RESUMEN

Objetivo: Comparar la evolución de factores cognitivos, físicos y psicológicos en ancianos, relacionando la práctica de Ejercicios Físicos Convencionales con Realidad Virtual. Métodos: Individuos mayores de 70 años, ambos sexos. Grupo 1 Ejercicio de Realidad Virtual + Ejercicio Físico Convencional y Grupo 2 Ejercicio Físico Convencional. Intervención Ejercicio de Realidad Virtual se basa en el software de marcha estacionaria virtual Street View y la intervención Ejercicio Físico Convencional se basa en la marcha convencional en 4 meses de intervención en 24 participantes. Resultados: Obtuvimos en el grupo Ejercicio de Realidad Virtual + Ejercicio Físico Convencional mejoría en función ejecutiva (p=0,001), relación con la tecnología (0,040), satisfacción con la vida (p=0,001), capacidad física (p=0,001), mientras que la variable calidad de vida no mostró efecto de la intervención (p=0,171). Conclusión: Así, mostramos cómo la intervención de Realidad Virtual ayuda a mejorar el rendimiento físico, funcional y psicológico de en ancianos.

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INTRODUCTION

Several studies and research have addressed and evidenced the benefits that regular physical exercise (PE) brings to older people[1, 2, 3].

Several strategies have been developed to motivate and increase PE directed to this population. One of them is Virtual Reality (VR). Already considered an innovative and motivational method, VR acts in interventions to improve the physical, cognitive, and psychological capacities of healthy older people or those in need of rehabilitation and even combat sedentary lifestyles[4].

In a three-dimensional and multidimensional way, VR naturally provides human-machine interaction to the users, simulating everyday actions, conventional cognitive games, and virtual PE, promoting stimuli in the training of cognitive aspects, such as attention and memory, physical aspects, such as gait and balance, psychological aspects, such as life satisfaction and quality in the aging process[5].

Studies that associate virtual games and acute cardiovascular responses report that the exercises proposed by the software follow the parameters of the American College of Sports Medicine (ACMS), when it comes to the maintenance and increase of cardiorespiratory fitness in older people[6].

Several stimuli are used to successfully treat the Central Nervous System (CNS). Because of this, VR is an important ally in the recovery of the CNS, as several stimuli are offered to the users (motor, visual, auditory sensory), due to its interaction with the virtual environment[7].

Activities involving technology, such as the use of smartphones, computers, and tablets, are increasingly present in our daily lives, and the daily lives of elderly people are no different. Therefore, the elderly population needs to be able to deal with the challenges inherent to technology. VR helps to break down the barriers that we observe in the elderly person's relationship with technology.

Without risk to participants and being able to provide more complex training, VR is a promising tool in encouraging and maintaining regular PE for older people, promoting independence and autonomy during old age. In view of this, the objective of this study was to evaluate the physical, cognitive, and emotional benefits of 24 older people through virtual and conventional PE.

METHODS

Participants

The research is being carried out with older people over 70 years of age, with their consent, as volunteers, and awareness of the whole process. They signed the Informed Consent Form (ICF), which states that the data collected will be protected by scientific and professional secrecy.

The inclusion criteria to participate in the research are being aged 70 years or more, PE practitioners, obtaining a score higher than the cutoff point (25 points) of the Mini-Mental State Examination[8], and not having dementia according to The Clinical Dementia Rating (CDR)[9]. As exclusion criteria, the older people cannot have previous diagnoses of diseases or severe physical and mental deficits, which prevents participation in the research stages. Participants are invited at the beginning of the workshops offered by the UniversIDADE program and contacted by telephone.

The sample is being formed by participants who do not present cognitive disorders and physical limitations. All are students of the University of the Third Age program, which has approximately 1,000 participants in total and is located on the premises of the State University of Campinas (UNICAMP). This program offers free integrative and interdisciplinary workshops with five major thematic areas: culture (reading, art history workshops), sport (water aerobics, volleyball, Pilates), leisure (sewing, origami, craftsmanship workshops), physical and mental health (educational lectures), sociocultural/income generation (financial planning, among others). The program aims to offer activities to people over 50 years of age, thus encouraging socialization, the search for new knowledge and physical and mental health[1].

24 Participants were randomly divided into two groups, Virtual Physical Exercise Group + Conventional Physical Exercise Group (VPE+CPE) and Conventional Physical Exercise Group (CPE).

Instruments

- Anamnesis
- Mini-Mental State Examination (MMSE)[8].
- CDR Scale (Clinical Dementia Rating)[9].
- Stroop Test[10].
- Short Physical Performance Battery (SPPB)[11].
- Inventory of Attitudes Related Technology (IART)[12]
- Life Satisfaction Scale (LSS)[13].
- Quality of Life Questionnaire - Older people (WHOQoL-OLD)[14].

Procedures

After the approval of CEP-UNICAMP and Unicamp's UniversIDADE Program, we prepared the work schedule. The questionnaires are being applied to the research participants in the University building at the beginning of the research and 4 months at the end of the intervention. The training used is described below:

Virtual Reality Exercise Intervention:

The training for this group consists of sessions three times a week, and each session is divided as follows: in the first 5 minutes, the participants perform stretching and body warm-up. They perform the walking exercise, lasting 22 minutes. Soon after, they perform the stationary march through the eMaps software for 8 minutes.

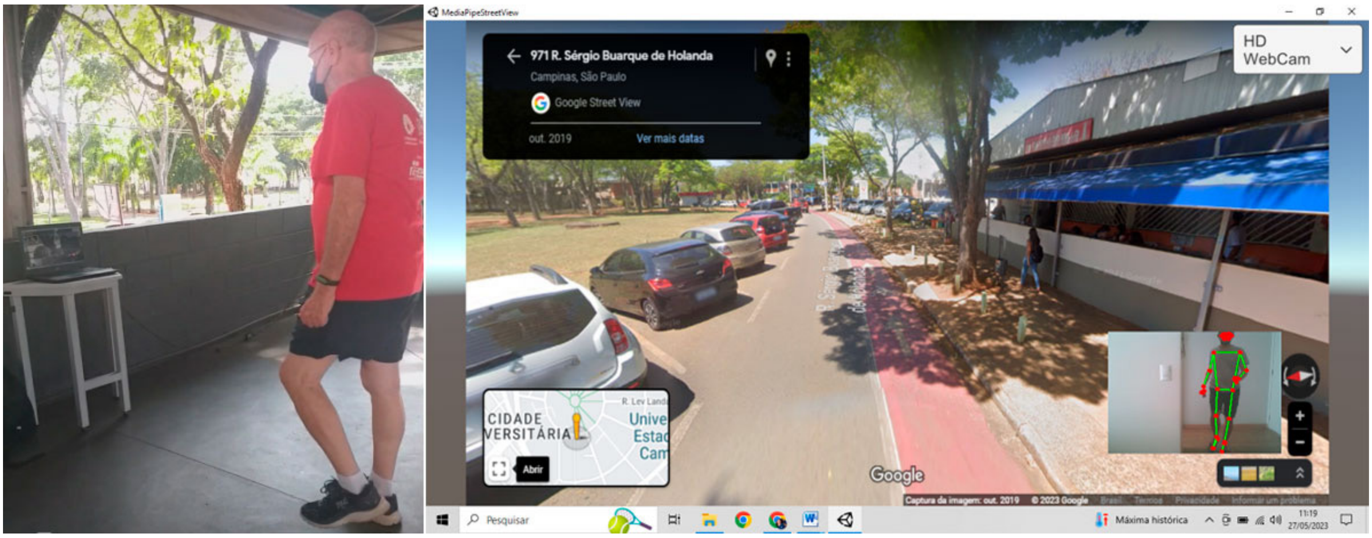
[1] https://www.programa-universidade.unicamp.br/

The challenge proposed was to carry out the stationary walk until reaching, in the virtual environment, the square where the participants carried out the conventional walk—finally, 5 minutes of muscle relaxation, totaling 40 minutes each session, 20 sessions in total.

Participants who performed the VRE controlled stationary walking movements through an avatar. The eMaps Software is carried out through the Google Street View Tool, being one of the tools of the BRAINN_XR Collection compilation that provides the user with human-computer interaction through motor and cognitive stimuli in teaching-learning, adding neuromuscular and physical rehabilitation through active entertainment[15].

The flexion movements of the hip and knee cause the participant to "move by walking" through the map and to change direction; the lateral flexion of the trunk (right or left) is performed as shown in Figure 1. All participants will present a medical certificate that they are able to practice PE. The VRE sessions took place in the building of the UniversIDADE of the 3rd-age program, UNICAMP.

Figure 1 - eMaps Software application that can control Google Street View using the lower



Source: Brandão et al (2018)

Conventional Physical Exercise Intervention:

Participants performed stretching and body warm-ups for 5 minutes. Then, they performed the walking exercise, lasting 30 minutes. Finally, 5 minutes of muscle relaxation, totaling 40 minutes each session. Conventional walking sessions were performed three times a week for five months in the PE group. All participants presented a medical certificate that they were able to practice PE. Conventional walking sessions took place at Peace Square, Unicamp.

Due to the health emergency resulting from the COVID-19 pandemic, preventive measures such as physical distance, use of a face mask and hand sanitizer were adopted during data collection and interventions, providing the necessary care and preserving the integrity of research participants and researchers.

Statistical Analysis

Descriptive statistics were used to characterize the study variables. The Shapiro-Wilk and Mauchly tests were used to identify normality and sphericity, respectively. Generalized Estimating Equations (GEE) were used to verify the effects of time (i.e. pre and post) and interaction (i.e. group x time) on the continuous outcome measures. In each GEE, different distributions for the dependent variables were compared using AIC/BIC and graphical analysis of the residuals (Q-Q plot). The effect size was estimated by Cohen's d, where values up to 0.19 are "insignificant", between 0.20-0.49 "small", 0.50-0.79 "medium", 0.80-1.29 "large" and greater than 1.30 "very large" (Rosenthal, 1996). The level of statistical significance adopted was 5% and all the analyses were carried out in JAMOVI, version 2.3.16.

RESULTS AND DISCUSSION

Eleven participants in the control group (CPE) and 13 participants in the experimental group (VRE+CPE) with a mean age of 73.4 years (SD= ±2.29) participated in the interventions, seven women and four men in the CPE and eight women and five men in the VRE+CPE. The data are detailed in Table 1.

Table 1 - Characterization of the VRE+ CPE group sample

Characteristics	CPE Group	VRE+ CPE Group
Mean age (years)	73.4	73.4
Mean Schooling	High school degree	High school degree
Female	7	8
Male	4	5

Caption: VRE = Exercise + Virtual Reality; CPE = Conventional Physical Exercise.

Intergroup analysis

According to GEE (Generalized Estimating Equations), in the Stroop test, there was an effect of time [F(1, 23)=27.32; p=0.001], but there was no effect of interaction [F(1, 23)=0.58; p= 0.455]. In the IART variable, there was an effect of time [F(1, 23)=4.75; p=0.040], but there was no effect of interaction [F(1, 23)=3.08; p=0.092]. In the WHOQOL-OLD variable, there was no effect of time [F(1, 23)=2.00; p=0.171], and there was no effect of interaction [F(1, 23)=2.61; p=0.119]. For the life satisfaction variable, there was no effect of time [X^2 of Wald (1)=0.06; p=0.795], but there was an effect of interaction [X^2 of Wald(1)=16.86; p<0.001]. In the SPPB variable, there was an effect of time [X^2 of Wald(1)=12.03; p<0.001] and there was an effect of interaction [Wald(1)=6.632; p=0.010].

Table 2 - Effect of different interventions on cognitive, physical, and psychological capacities in older people

Variables	Group	Pre - post (SE)	Cohen d	P time	P interaction
STROOP	Experimental	-9.38 (2.12)	-0.49	<0.001*	0.455
	Control	-7.00 (2.31)	-0.49		
SPPB	Experimental	-2.97 (0.59)	-1.01	<0.001*	0.010*
	Control	-0.44 (0.79)	-0.22		
IART	Experimental	-5.08 (1.75)	-0.67	0.040*	0.092
	Control	-0.54 (1.90)	-0.08		
LIFE SATISFACTION	Experimental	-1.82 (0.55)	-0.37	0.795	<0.001*
	Control	1.60 (0.62)	0.41		
WHOQOL-OLD	Experimental	-4.08 (1.82)	-0.46	0.171	0.119
	Control	0.27 (1.98)	0.02		

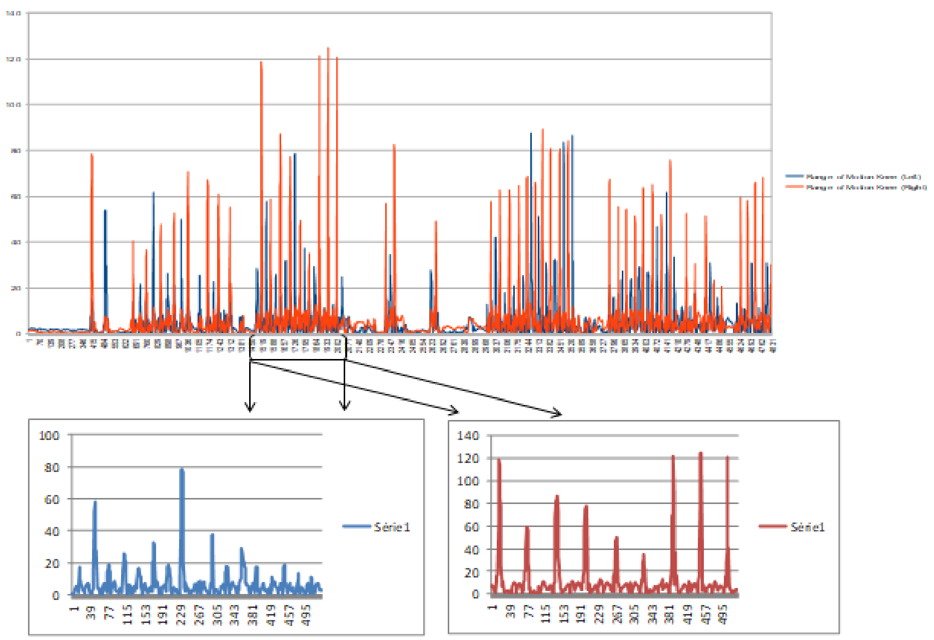
Caption: SPPB = Physical Performance Battery; IART = Inventory of attitudes related to technology; SATISF. LIFE = Life Satisfaction Questionnaire; WHOQOL-OLD = World Health Organization Quality of Life - OLD; SE = Standard Error; Cohen d = ≤ 0.1= "null"; 0.1-0.20 = "very small"; 0.21-0.5 = "small" 0.51-0.80 = "medium"; 0.81-1.2 = "large"; 1.21-2.0 = "very large"; > 2.0 = "extreme"

Motion Range Software eMaps (Streetview)

The following information refers to the recording made by the motion sensors (BRAINN_XR software) of the participant's stationary gait during a VR intervention session, in which they are represented by frames, explained in the next paragraph. The joints involved are the tibiofemoral and the patellofemoral (knees), which are hinge joints, and the main movements are flexion and extension in the sagittal plane. The graphs presented in this session show the range of motion (ROM) of the left knee joint (blue) and right knee joint (red). The greater the knee flexion, the greater the ROM[15].

The following data were collected at the end of the interventions (after four months) in the control and experimental groups. A range was selected for the graphical representation of the data, being in the lower graphs, frame 1 represents frame 1450 of the upper graph, and frame 495 represents frame 2002 of the upper graph.

Graph 1 - Range of motion of knee flexion



Caption: left knee range of motion (blue), right knee range of motion (red). Participant number 12, female, 70 years old, control group.

It is pertinent to emphasize the importance of range of motion for older people because the greater the amplitude of knee flexion, the greater the individual's stride, decreasing the risk of falling when moving. Some authors [20, 21] evaluate and associate the quality of the step with the degree of frailty of the older person. Drummond et al (2020) [16], evaluated the fear of falls in older people through GAITRite® (software that measures and records spatial and temporal parameters while the participant walks on a computerized treadmill) and found that participants with greater slowness, shorter length and pace of the stride, were more afraid of falling when moving. Vieira et al (2013) [17] emphasize that fear and the risk of falling are predictors of frailty, leading older people to move less and may lead to other harms associated with the worsening of neuromotor skills and functional performance. Thus, we show the importance of measuring the range of motion, especially during an intervention aimed at improving the physical capacity of this population.

This research aimed to demonstrate how virtual PE associated with conventional PE increases physical, cognitive and psychological capacities in older people. Thus, the experimental group performed the virtual PE for 8 minutes through the eMaps software that stimulates stationary gait and also performed the conventional PE of walking, stretching, and relaxation for 22 minutes, while the control group was subjected only to the conventional physical exercise described above, for 30 minutes.

We can observe that executive function, evaluated through the Stroop Test (colors and words), had an effect of time, significantly improving cognition in the experimental group ($p = 0.001$). They corroborate the study by Anderson-Hanley et al. (2018) [18] that randomly allocated 111 older people, with a mean age of 78 years, into 3 groups, in which all groups had cognitive demands, but only 2 groups did Cybercycle (stationary cycling VR software) with mild (group 1) and moderate (group 2) levels for 6 months and observed better results in executive function (Stroop Test) in group 2 participants (moderate Cybercycle associated with cognitive demand).

In the variables balance, lower limb strength, and gait speed measured by the SPPB, we observed that there was the effect of time ($p = 0.001$), through the interventions. It is not new that physical abilities improve with the practice of regular PE, but when we associate conventional PE with virtual PE, we notice the clear motivational difference to the practice of PE by older people. As also observed by Magna, Brandão, and Fernandes (2020) [4], motivation is the differential of VR for the increase of physical capacities and the incentive to continue practicing PE regularly. Thus, VR is an excellent tool for physical education professionals, bringing innovation and more options to increase interventions/training, and motivate and promote regular PE for the older population.

In attitudes related to technology, we noticed that the relationship of participants in the experimental group with technology was more significant compared to participants in the control group ($p = 0.040$). This shows that the interaction with the eMaps software can influence the challenges inherent in the technology that the participants encountered in their daily lives. The study by De Oliveira Alvaro et al. (2022) [5] analyzed the relationship of older people with technology, putting on the agenda the facilitators and barriers that participants had about technology. They observed that barriers were associated with prior understanding and inadequate inclusion of technology, while participants who were more familiar with technology, the attentional factor, and the way in which inclusion was made to technology, helped in the better acceptance of participants to the technological demands of everyday life.

Here, we emphasize the importance of the appropriate choice of software in this study, because the software simulated a habitual walking movement, making interaction with technology as natural as possible. Nowadays, with technological advancement, the older people population needs to be prepared for the challenges inherent in technology, benefiting from the independence it provides, such as shopping on the internet, requesting a car for travel, ordering a meal to deliver at home, among others, facilitating daily demands.

When we talk about life satisfaction, we see in this study that the association of virtual and conventional interventions brought significant results through the interaction of the participants with the activities proposed during the 4 months of research ($p = 0.001$). Studies investigating how life satisfaction interacts with interventions involving VR are scarce in the literature because when addressing emotional aspects, the quality-of-life variable is the most studied emotional aspect in older people. Thus, we emphasize the importance of this study in the analysis of VR intervention in life satisfaction. As we have seen, it was promising and deserves attention to measure not only the quality of life as an emotional aspect, but also life satisfaction to analyze more broadly the emotional issues of this population.

In the variable quality of life, measured through the WHOQoL-OLD, we did not observe significant change before and after the interventions ($p=0.119$). However, we emphasize the importance of studying the emotional aspects of the aging process. Tollár et al. (2019)[19] in your research, even not observing changes in this emotional aspect after VR interventions in healthy older people, speak of the importance of studying the quality of life of the older person because the aging process can not only be seen in the physical or cognitive aspect, but also in the emotions triggered during this phase of life. The study by Santana et al. (2015)[20] demonstrates a small but significant improvement in quality of life measured by the PDQ-39 questionnaire (Parkinson Disease Questionnaire) after intervention by Microsoft® non-immersive VR games, which required physical capabilities (Kinect Sports, Your Shape – Fitness Involved and Kinect Adventures) in older people with mean age of 64 years with Parkinson's Disease in the early stages of the disease, revealing that VR intervention can increase quality of life in older people with some impairment.

We can observe that VR brings several benefits to the older population. Here we emphasize the importance of developing public policies that use VR to increase and innovate programs and actions aimed at older people, not only at a small portion of the population that can hire private services but leading to VR for all.

CONCLUSION

The objective of this study was to analyze whether VR associated with CPE improved physical, cognitive, and psychological capabilities in elderly people, and we measured that this association increased lower limb strength, balance and gait, executive function and satisfaction with life. Having VR as a tool to assist with interventions, care, and approaches is a great gain for professionals in the area of aging. In addition to the motivational aspect, we also see that VR encourages the relationship of older people with technology, including them to the current and future technological advancement to keep them engaged with the challenges inherent in technology. With everything, we conclude that virtual PE associated with conventional PE is a promising and important intervention for older people.

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