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Verification of the Effectiveness of Virtual Reality in the Intrinsic Factors on the Risk of Falls in Healthy Elderly: Systematic Review

Diego Eduardo dos Santos[1], Tiago Eduardo dos Santos[2], Laisa Liane Paineiras-Domingos[3,4], Marcia Guimarães Crossetti[1], Celeste Maria Thomaz Campos[5], Gabriel Gomes Maia[6], Kelly Cristina da Silva Ribeiro[2] and Laudicéa Henriques da Silva[2]*

[1]Physiotherapist, Longevus Centro Clinico Integrado - Rio de Janeiro, RJ, Brazil

[2]Physiotherapist, Hospital Estadual Getulio Vargas - Rio de Janeiro, RJ, Brazil

[3]Programa de Pós-Garduação em Ciências Médicas, Faculdade de Ciências Médicas, Universidade do Estado do Rio de Janeiro, RJ, Brazil

[4]Laboratório de Vibrações Mecânicas e Práticas Integrativas, Instituto de Biologia Roberto Alcântara Gomes, Universidade do Estado do Rio de Janeiro, Faculdade Bezerra de Araújo, Rio de Janeiro, RJ, Brazil

[5]Doctor Geriatric, Longevus Centro Clinico Integrado - Rio de Janeiro, RJ, Brazil

[6]Physiotherapist, Hospital Univertario Pedro Ernesto Universidade do Estado do Rio de Janeiro, RJ, Brazil

Abstract

The falls are of great importance in the population scenario, by involving a representative number of elderly and constituting one of the major geriatric syndromes and one of the greatest public health problems. The falls are defined as an unintentional contact with the supporting surface, resulting from the change of the position of the individual to a lower level in relation to his initial position, without any determinant intrinsic factor or any unavoidable accident and without loss of consciousness, being the elderly the most affected. The causes are multifactorial, divided into intrinsic and extrinsic risk factors or, according to the World Health Organization, into biological, behavioral, environmental and socioeconomic conditions.

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Correspondence:

Diego Eduardo dos Santos, Physiotherapist Longevusi Clinical Center- Rio de Janeiro, Brazil, E-mail: eudardosantos17@gmail.com

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Introduction

The falls are of great importance in the population scenario, by involving a representative number of elderly and constituting one of the major geriatric syndromes and one of the greatest public health problems [1]. In addition to being related to increased morbidity and mortality in old age, it is associated with restriction on mobility, fractures, depression, functional disability, loss of independence and autonomy, institutionalization and decline in the quality of life [2,3].

The falls are defined as an unintentional contact with the supporting surface, resulting from the change of the position of the individual to a lower level in relation to his initial position, without any determinant intrinsic factor or any unavoidable accident and without loss of consciousness, being the elderly the most affected [3]. The causes are multifactorial, divided into intrinsic and extrinsic risk factors or, according to the World Health Organization, into biological, behavioral, environmental and socioeconomic conditions [4].

We can highlight among the intrinsic factors the physiological alterations due to the advanced age (muscle weakness, lack of balance and motor coordination, gait disorders, functional limitations, pathological conditions and physical inactivity), cognitive impairment of female and drug interactions [5,6]. Among these factors, there are those we can call modifiable factors through physical exercise and functional therapeutic activities.

In relation to the benefits of physical exercise for the elderly population, we can highlight the attenuation of the process of physiological functions decline arising from aging, the improvement of the respiratory and cardiac capacity, time of reaction, muscular strength, cognitive, social and maintenance or improvement of functional capacity enabling the performance of daily activities independently as well as an increase in the quality of life [7-9].

The Virtual Reality (VR) is a kind of physical exercise and a non-conventional therapeutic supplement, which has been promoting various benefits in the elderly population, including the prevention of the risk of falls [10,11]. It is defined as a computational technology of interactive graphic images that provides the user virtual experiences that are similar to reality by means of visual and auditory feedback [12]. This fun interactive experience with active video games which require the movement of the entire body and with therapeutic purposes is called Exergames, and

Table 1: Characteristics of selected studies for the systematic review.

Author/Year	Number of Participants	Target	Age	Type of Intervention	Virtual Reality	The Intervention Period	Conclusion
Mussato et al. [17]	10	Analyze the influence of virtual reality games on the balance and functional capacity of healthy elderly.	66 ± 4.4	Nintendo wifitxcontrol	Wifit- 4 balance games	10 sessions per 30 minutes	The results showed no changes in the stabilometric variables after treatment with Wii Fit. There was a difference between the pre and post intervention for the experimental group for both the test of Unipodal Support as to the TUG, but there was no difference when compared with the control group.
Pluchino et al. [18]	40	Compare the results of the balance and postural control between the wii fit, exercise program and Tai Chi program	72.5 ± 8.40	ExerciseProgram x tai chi x Nintendo wi	Wi- wifit 4 categories: yoga, strength training, aerobics and balance games	2 sessions per week with a 60 minutes duration, being 5 minutes warn up and 5 minutes of cooldown for 8 for consecutive	No significant differences were observed between the groups on response variables at the beginning of the study.
Bieryla, Dold [19]	12	Check the use of Wii Balance Board with the Wii Fit for improvement of balance in the elderly and maintaining them	81.5 ± 5.5	Wifit xcontrol group	Wii Fit-Wii Balance Board- yoga, aerobic and balance games	3 sessions per week with a 35 to 40-minute duration, for 3weeks	The experimental group increased significantly the BBS after training, while the control group did not. There was no significant change to any of the groups with FAB, FRT and TUG.
Karahan AY et al. [20]	90	Compare the effect of the Exergaming using XBox Kinect, with a homecare exercise program for elderly	71.3 ± 6.1	Xbox Kinect x home exercise program	Kinect Adventures, Kinect Sports, and Kinect Sports Season	5 sessions per week of 30 minutes, for 6 weeks	EG can be considered as a secure alternative, fun and sustainable exercise program, that can have positive effects on the balance, functional walk and quality of life of geriatric individuals
Sato et al. [21]	57	Check the effect of Exergaming on healthy elderly	70.07 ± 5.35	Kinect and Kinect SDK 1.5 version (Microsoft) X control	Kinect -balance and strength exercises	Two to three times a week, up to a total of 24 times, from 40 min to 1 hour, during 12 weeks	As a result, it was noticed the improvement in motor functions of the participants, including muscle strength of lower limbs, walking and balance.

Abbrevations: TUG: Timed Up and Go; BBS: Berg Balance Scale; FRT: Functional Reach Test; FABS: Fullerton Advanced Balance Scale; EG: Exergames

it has provided a better patient adherence to treatment, prevention programs and social skills acquisition [13,14].

Currently, active games are used for body movement, like the Nintendo Wii, Play Station Move, Xbox 360 Kinect, besides other companies that do not have so much visibility worldwide. The objective of this study is to verify the effectiveness of the VR in the modifiable intrinsic factors in the risk of falls in the elderly, as motor coordination, cognition, social interaction, balance, muscle strength and functional capacity [15].

Search Strategy

The search strategy included the electronic databases such as SciELO, PubMed, LILACS and PEDro (Physiotherapy Evidence Database). For the search of scientific studies, it was used a combination of the terms and their descriptors as: videogame, X-box, Kinect, Play Station, Nintendo Wii, Virtual Reality, Balance, Motor Control, Fall, Prevention, Elderly, Motor Coordination, Posture and Psychological.

Inclusion criteria

Randomized clinical trials that applied VR as an intervention focusing on the improvement of intrinsic risk factors of falls in healthy elderly, with age equal to or above 60, were selected for eligibility.

Analyzed outcomes

The articles included in this study have the following analyzed outcomes: Timed Up and Go (TUG), Berg Balance Scale (BBS), Falls Efficacy Scale (EEQ), Muscle Strength, Balance Tests, Tinetti Balance Test (Performance Oriented Mobility Assessment - POMA), Mini Mental State Examination (MMSE), Functional Reach Test (FRT) and quality of life.

Exclusion criteria

Were excluded from this study, systematic reviews, meta-analyzes, reports or case studies, short publications, and studies that used children, adolescents and young adults as sample.

Selection of study

Two authors independently selected studies for inclusion, examining the controlled and randomized clinical trials found through the analysis of the titles and abstracts. All studies considered relevant had their texts obtained in full and, based on the information contained; those that met the criteria for inclusion were selected.

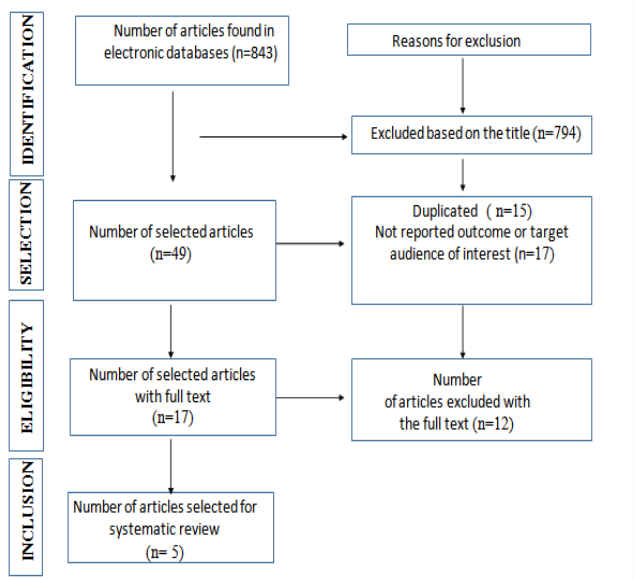

Figure1: Flowchart of identification and selection of studies for the systematic review.

Discordances between the authors were absolved by the analysis of a third author.

Methodological Evaluation

Scale of JADAD

Scale of quality described by JADAD et al. was developed using the nominal group consensus technique. Having a list of constant items at various scales and list of criteria for the evaluation of randomized clinical trials, consisting of a multidisciplinary panel, prepared by six specialists, who summarized it in three items, directly related to the reduction of tendencies (internal validity) This quality assessment instrument has two options: yes or no. In the following questions:

1. Was the study described as randomized?

2. Was the study described as double-blind?

3. Was there a description of exclusions and losses?

4. Was the method for generating the randomization sequence described and appropriate?

5. Was the double-blind method described and appropriate? [16]

Results

A total of 843 articles were identified in the survey, of these, 749 were excluded based on the title for not having any relation to the topic under study, and 94 were selected for summary reading. Based on the summaries, 13 studies were considered potentially relevant and eligible for a full review (Figure 1). However, 8 studies were excluded for lack of data or incomplete data or because they did not have a control group, leaving only 5 articles for systematic review, totaling 209 patients. The description of the studies is presented in Table 1.

Methodological quality

Table 2 shows the scores referring to the methodological quality of the studies included in the present review. There are 4 high quality articles selected and one low quality.

For a description of the outcomes analyzed, we separated the results in intrinsic factors that are linked to skeletal muscles, mobility variables and functional capacity (Timed Up and Go, BBS, TSL 30 seconds, POMA, FRT and UST), and, also, psychological and quality of life variables.

Table 2: Methodological Quality Assessment through the Scale of JADAD.

Author/Year	1º	2º	3º	4 º	5º	Total
Mussato et al. [17]				1		1
Pluchino et al. [18]	1	1	1	1	1	5
Bierylaand, Dold [19]	1	1	1	1	1	5
Karahan AY et al. [20]	1	1	1	1	1	5
Sato et al. [21]	1	1	1	1	1	5

Timed up and go (TUG) and berg balance scale (BBS)

The TUG is a mobility test, able to measure the functional capacity of the elderly, being correlated to balance, gait or walking tests and daily activities. The shorter the time spent to perform the test, the better the functional capacity of the individual [22]. The five studies selected for this review used this test, Karahan AY et al. [20] and Sato et al. [21] obtained statistically significant results, with $p<0.05$, as well as the BBS validated instrument of balance functional evaluation composed of 14 tasks with five items each, and a score of 0-4 for each task: 0- is incapable of accomplishing the task and 4-performs the task independently. The total score ranges from 0 to 56 points. The lower the score, the higher the risk for falls; the higher the performance, the better [23].

30-Second sit to stand test (SST) and functional reach test (FRT)

The 30-Second Sit to Stand Test is an instrument that has a simple application, which evaluates the physical performance of lower limbs strength, by the maximum number of repetitions of the Sit to Stand from the chair in 30 seconds [24]. In this variable Bieryla and Dold [19], and Sato et al. [21] achieved significant results. The low cost and easy application of the FRT aims to identify the dynamic changes of postural control. None of the selected studies obtained statistically significant results in this test.

Gait and balance evaluation oriented by performance (POMA) and unipodal support test (UST)

POMA was developed by Tinetti in 1986 [25,26] and its objective is to identify the risk factors that cause lack of balance and mobility in the elderly, determining the probability of falling [27], being divided into two parts: gait and balance evaluation [28]. The UST asks for the individual to find balance on only one foot with the eyes open for no more than 30 sec [27]. Studies that evaluated these variables did not.

Fall efficacy scale and quality of life

Only Pluchino et al. [18] evaluated the psychological aspects in relation to fall, through the Fall Efficacy Scale (FES), without a statistically significant result ($p>0.086$). The FES consists of 14 questions that provide self-assessments of internal and external activities. Questions are used to determine the confidence levels of the elderly in each activity [29]. And Karahan AY et al. [19] evaluated the quality of life through the Quality of Life Inventory-SF36, which is an inventory that assesses 8 distinct aspects: functional capacity, physical aspects, emotional aspects, pain, general health status, vitality, social aspects, and mental health [30]. After the exercise program, with statistically significant results in the items regarding physical and social aspects and general perception of health, in post-exercise

Table 3: Intrinsic factors that relate to skeletal muscles variables, mobility and functional capacity.
The data of the table 3 were expressed in mean ± SD or mean (median). Each test was assessed at two moments of the protocol: pre and post intervention.

	Intrinsic factors Mean ± SD or Mean (median)						
	TUG (s)	BBS	30 sec SST	POMA gait	POMA balance	FRT (cm)	UST (s)
Mussato et al.,2012 [17]	8.2 ± 0.4						10.6 ± 4.7
	6.8 ± 0.5						16 ± 4.5
	p=0.70						p=0.65
Pluchino et al., 2012 [18]	7.71 ± 2.34	50 (47.5 to 51.5)		11.75 ± 1.16	15.13 ± 1.46	35.18 ± 8.64	
	8.18 ± 2.44	53 (52-54)		11.95 ± 0.35	15.13 ± 2.10	39.71 ± 15.90	
	p ≥ 0.05	p=0.0711		p=0.093	p=0.027	p=0.060	
Bieryla and Dold, 2013 [19]	12.8(12.2 to14.9)		11.5 ± 3.8			24.3 (22.3 to 32.7)	
	11.2(10.6 to 14.3)		13.3 ± 3.2			23.5 (22.3 to 29.7)	
	p=0.173		p=0.01			p=0.902	
Sato et al., 2015 [21]	10.3 ± 3.8	55.31 (56.00)	17.14 (17.50)				
	9.0 ± 3.2	55.97 (56.00)	24.04 (23.50)				
	P=0.01	P ≤ 0.01	P ≤ 0.01				
Karahanet al., 2015 [20]	8.70 ± 1.71	49.85 ± 3.88					
	8.04 ± 16.47	54.91 ± 2.67					
	P ≤ 0.05	P ≤ 0.05					

Subtitle: Timed Up and Go (TUG); Berg Balance Scale (BBS); Functional Reach Test (FRT); 30-second Sit-to-Stand Test (30-sec SST);Gait and Balance Evaluation Oriented by Performance(POMA); centimeters (cm); seconds (s) p-value ≤ 0.05.

assessments, all with p<0.05 (Table 3).

Discussion

According to the World Health Organization - WHO, the assessment is conceptualized as a "Systematic and objective process of determination of the relevance, effectiveness, efficiency and impact of activities based on their goals [31]. And, in this way, we assess the need for intervention of the sample, assessment tools and the method of intervention by virtual reality.

Analysis of the need for intervention of the sample and assessment tools

The TUG's objective is to evaluate the mobility and the functional balance [32,33]. And, according to Bischoff [34] the expectation for the elderly with disabilities or fragile, with partial independence and with low risk of falls is from 11 to 20 seconds and, a time over 20 seconds suggests that the elderly presents an important physical mobility deficit and risk of falls, so the elderly in the studies selected for this review at the initial evaluation, presented a low risk of falls. Sato et al. [21] and Karahan AY et al. [20] obtained statistically significant results, as well as Jorgensen et al. [35], with p=0.01, in a randomized clinical trial with 58 elderly, but some of them had pulmonary, cardiac, neurological and muscular skeletal problems. Also demonstrated by Laver et al. [36] with hospitalized patients, the multivariate analysis suggested that participants using the interactive games program have improved more in the TUG (p=0.048) than those participants who received conventional physiotherapy.

In relation to BBS, Shumway-Cook and Woolacott [37] suggest that from a cutoff point between 53 and 46 points, there is low to moderate risk for falls, and that a score below 46 points indicates a high risk for falls. This way, only the study of Karahan AY et al. [20], had elderly patients with risk of falls, and obtained a statistically significant result, after the intervention of the Xbox 360 Kinect video game. Zalecki et al. [38] also obtained significant results mostly with patients with Parkinson Disease and Cerebral Vascular Accident. As Esculier et al. [39], who compared elderly patients to Parkinson Disease and healthy ones, the DP group significantly, improved the results in TUG, unipodal posture, the 10-meter walk test, POMA and strength platform and two more variables at the end of a 6-week training program. The group of healthy elderly significantly improved in TUG, unipodal posture and in the mobility evaluation.

In relation to the tools used, there are currently various instruments to predict the risk of falls, but Karuka H et al. [40], in a cross-sectional and observational study of selected sample by convenience, with 30 healthy volunteer ladies from the community, hygienic, with different levels of physical condition, between 61 and 74 years of age, concluded that the balance evaluation tests of elderly (BBS, TUG, POMA and FRT) are complementary, having in view that they are not strongly correlated and show distinct characteristics and limitations, thus, it is necessary a joint application of these instruments to better assess the balance in the elderly and in identifying the elderly with increased susceptibility to falls.

In relation to the sample of selected studies, an intervention by virtual reality was necessary, concerning the studies that demonstrate that the healthy elders had benefits in the evaluation pre- and post-intervention, in relation to the group itself. But, for a statistically significant result, in comparison to the control group, it would be necessary a sample of elderly people of medium and high risk of falls, as well as patients with neurological, cardiovascular and musculoskeletal problems and, after an initial assessment, the participation of the same group is suggested in the studies with virtual reality.

A method of intervention by virtual reality and comparison with other revisions

There was no consensus on the treatment program or intervention by virtual reality, the same was observed by other revisions made by Itakussu EY et al. [41] and Pope Z et al. [14], where we can suggest, for prescription of intervention with virtual reality, the following

variables, after the application of contraindications and indications: use of games that enhance and move closer to the daily life activities of the selected sample and that develop motor skills to decrease the risk of falls; previous determination of difficulty levels for each game from the easiest to the most difficult one, number of daily games, or per session, time spent on each game (even if the individual had reached the maximum score), duration of time of each session, the number of sessions a week, intervention period; as well as a longitudinal follow-up and assessment of the quality of life.

Regarding the adherence to the virtual reality program, a higher adherence to the control group during and after the intervention programs was verified, and no report of any adverse event, on the selected studies for this review.

Conclusion

The physiological reduction of the elderly to perform daily activities can be modified through an exercise program because it provides various psychological benefits such as increased confidence, self-esteem, and mental and physical health through the modification of intrinsic factors. The VR is an effective way to prevent falls among the elderly because it increases balance, mobility, motor coordination and flexibility with good acceptability, accession and promotes an increase in the quality of life in a non-conventional mode.

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