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Research Article

Effects of Conventional Proprioceptive Training and Virtual Reality on Functionality and Fear of Falling in Elderly Women: Randomized Clinical Trial

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Abstract...

Aim: The aim fo this study was to evaluate and compare the effects of conventional proprioceptive training and virtual reality on the functionality and fear of falling of elderly women.

Methods: This was a randomized controlled clinical trial, with 50 elderly women randomized into three groups: The conventional proprioception group performed exercises involving gait, balance and proprioception, organized as a circuit with seven stations. The virtual reality group performed exercises through the Microsoft® Xbox One console, using Kinect Sports Rivals, a game with five sports activities: jet ski racing, climbing, soccer, bowling, and tennis. The outcomes studied, composed of balance Berg Balance Scale (BBS), functional mobility Time Up and Go Test (TUGT), functional physical performance of the lower limbs Short Physical Performance Battery (SPPB) and fear of falling Falls Efficacy Scale - International – Brazil (FES-I-Brazil). Intragroup comparisons were performed using paired Student's T test or Wilcoxon test. Intergroup comparisons were performed by means of the one-way Analysis of Variance (ANOVA), Tukey's Post-hoc test, Analysis of Covariance (ANCOVA), Sidak's Post-hoc test, Kruskal-wallis, and Dunn's Post-hoc test, being $p \leq 0.05$.

Results: The conventional proprioceptive training group improved mobility, balance, physical performance, and reduced concern about fear of falling. The virtual reality group showed improvement in all outcomes of the study, with the exception of mobility assessed by TUGT. The control group did not show improvement in any of the study outcomes, and mobility (TUGT) showed a statistically significant worsening after the study period. When comparing the intergroup effects on the outcomes studied, there were no significant differences between the intervention groups.

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Conclusion: We conclude that both interventions can promote improved functionality and reduced fear-of-fall concerns in elderly women, with no significant difference between conventional and virtual training.

Keywords: Elderly; Functionality; Falls; Virtual Reality; Conventional physiotherapy.

Introduction

The characteristics of the aging process are biochemical, morphological, physiological and psychological alterations, which predispose individuals to the progressive loss of the ability to adapt to the environment, to the appearance and worsening of diseases, altering their motor and cognitive abilities [1]. Physiological alterations with impact on mobility, balance, and physical performance stand out, making the individual more susceptible to falls and the fear of falling, which can cause possible fractures and consequent immobility [2-5].

Physiological alterations caused by aging can be mitigated with the practice of physical exercises, since their benefits promote greater autonomy and quality of life in the elderly population [3,6,7]. Studies have evidenced that certain types of exercises, such as walking, balance, coordination, functional training, strengthening exercises, and other three-dimensional training programs are effective for improving balance in the elderly [8] muscle strength, mobility, and functional independence [9,10].

The conventional proprioceptive training promotes positive effects on functionality and, consequently, reduction of falls in the elderly [11-13]. Recently, the emergence of new technologies such as virtual reality, also known as "exergames", has been used in clinical practice with therapeutic purposes such as gait [14], balance [14,15], muscle strength [14,16], and falls [17,18].

Although conventional and virtual proprioceptive training are alternatives to reduce losses due to aging, there is no consensus in the scientific literature as to which modality provides better performance in functionality and consequently reduction of the fear of falling in elderly women. Therefore, this study aimed to evaluate and compare the effects of conventional proprioceptive training and virtual reality on the functionality and fear of falling of elderly women.

Methods

Study Design and Setting

This study was developed according to the recommendations of CONSORT (Consolidated Standards of Reporting Trials) [19]. It consists of a randomized controlled clinical trial, the sample was composed of elderly women participating in four Senior Citizenship Groups, located in the city of Jequié, Bahia, Brazil.

The choice for female participants was due to the observation during the visits to the groups that only two elderly men were attending the groups, thus making it impossible for them to participate, since this would compromise the homogeneity of the characteristics between the groups.

Sample

Participants

The sample size was defined based on the results of a pilot study with 5 elderly women in each group and considering as outcome the difference (i.e., performance before training or control - performance after training or control) in the Time Up Go Test (TUGT) (described ahead). For the sample size calculation, we considered α=0.05 and the power of the test (1-β) = 0.95, with 3 groups (control x conventional x exergame), which obtained a sample number of 36 individuals (i.e., 12 in each group). Considering the possibility of sample loss throughout the 8-week intervention, the sample size was estimated with a loss margin of 25% in each group, and therefore a sample number of 15 elderly women per group was expected (i.e., total sample size of 45 elderly women) (Figure 1). The sample size calculation was performed in the G*Power® version 3.1 software.

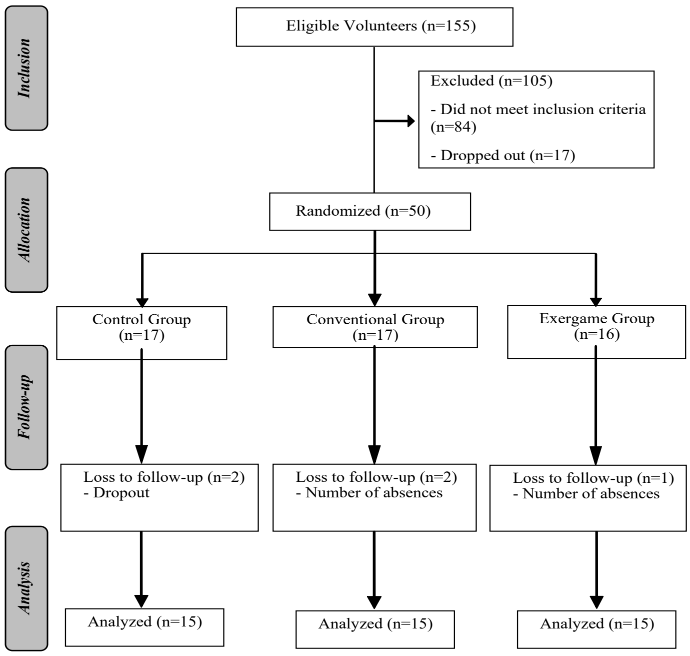

Figure 1: Flowchart of the study volunteers by stage.

As inclusion criteria, it was established that the elderly women should present: a) minimum age of 60 years and maximum of 79 years; b) had not been practicing any type of physical exercise (oriented and regular) in the last three months or had been practicing physical exercises, but not enough to be classified as active due to non-compliance with the recommendations regarding duration, i.e., less than 150 minutes per week [20]; c) absence of cognitive deficit assessed through the Mini-Mental State Examination (MMSE) [21], the version adapted for the Brazilian population. The absence of cognitive disorder followed the cut-off values according to education: Illiterate ≥

13 points, 1 to 8 incomplete years ≥ 18 points, and 8 years or more of schooling ≥ 26 points [22]; d) absence of diagnosis of diabetes mellitus; e) absence of vestibulopathies; f) absence of cardiovascular diseases limiting exercise; g) absence of any visual or auditory difficulty that would compromise the proposed training sessions; h) absence of skin lesions on the feet and amputations; i) absence of osteoarticular lesions that could hinder or make it difficult to carry out the training sessions; j) independent deambulation and locomotion without auxiliary devices; k) absence of claudication or any other alteration in the gait pattern for any reason; l) availability to attend the training sessions held throughout the study.

The following were excluded from the study: a) elderly women who had attended another proprioceptive rehabilitation program during the training or within the last three months; b) those who had participated in less than 75% of the training program.

Before the interventions, a pilot study was conducted with 15 elderly women, which allowed adjustments in the participants' training time, better handling of the resources used, and standardization of some evaluation methods. After screening the participants according to the established criteria, 50 elderly women remained in the sample, which were submitted to stratified randomization by age (60-69/70-79) and BMI (low/high). From the stratification, the participants were distributed into four groups: age (60-69) and low BMI, age (60-69) and high BMI, age (70-79) and low BMI, and age (70-79) and high BMI.

Subsequently, a code was created for each participant and randomization was performed in blocks of three individuals for each stratum. The blocks were randomized using Microsoft® Excel version 2013, and then the codes were distributed in three arms of the study (conventional group, exergame group, and control group). A researcher with no clinical involvement in the trial, thus ensuring the confidentiality of the allocation, performed the entire process.

Intervention protocol

The control and conventional groups were composed of 17 participants and the exergame group was composed of 16 participants, and at the end of the study each group ended with 15 participants. The losses were related to participation below 75% of the training program (three elderly women) and dropouts (two elderly women), totaling five losses (Figure 1).

In the present study, the blinding of the participants and the researchers was not possible, since both were present and experienced the execution of the proposed training sessions. However, blinding was possible for the evaluators, who did not know to which group each elderly woman was allocated. The researchers consisted of previously trained physical therapy students and physical therapists.

The control group (GCT), during the intervention period, did not participate in any training modality; the conventional group (GCV) participated in conventional proprioceptive training; and the exergame group (GEX) participated in proprioceptive training based on virtual realities.

The training was performed three times a week, during 8 weeks, for 24 sessions, duration of 50 minutes per session, with a minimum interval of 48 hours between each session. The training protocol was organized as follows: warm-up (10 min), proprioceptive training (30 min), and cool-down (10 min), with monitoring of blood pressure and heart rate before and after the activities.

Before the first session, the objectives of the activities were presented to the participants and, for the familiarization they were allowed to make one attempt per activity on the same day as the first session. During the first two sessions the elderly women were assisted verbally and manual contact from the researchers, helping them in the best and most correct way to move in order to reach the training objectives and promote postural correction.

The warm-up consisted of a walk (4 minutes) and stretching exercises for the muscles of the upper and lower limbs, and spine (6 minutes). The cooling down was performed with breathing exercises (5 minutes), and stretching exercises (5 minutes). The participants were warned not to alter their activities of daily living during the intervention period, thus avoiding possible influences of external factors on the outcomes of the research.

The training sessions were suspended in case the participants presented vertigo, malaise, muscle pain, increased blood pressure, or any other physical discomfort. At the end of the study, for ethical reasons, the CGT received conventional proprioceptive training under the same conditions as those established in the VGC protocol.

The conventional proprioceptive training protocol involved gait, balance, and proprioception training, and was spatially organized in the form of a circuit with different textures and obstacles, consisting of seven stations. The materials used were: 1 mattress of dimension 120 X 70 X 10 cm (station 1), 1 foam module - mini beam of dimension 190 X 22 X 10 cm (station 2), 4 agility rings with 42 cm diameter (station 3), 1 proprioceptive lateral board of dimension 60 X 36 X 8 cm (station 4), 2 agility cones of the dimensions 23 X 14 cm (station 5), 1 proprioceptive disc with a diameter of 40 cm (station 6), and 3 agility barriers of the dimensions 70 X 15/ 70 X 20/ 70 X 25 cm (station 7).

The elderly women participated, in groups of two or three, in specific exercises at each station that combined sensory and motor stimulation, as follows:

- Station 1: Lateral strides (right and left), forward and backward strides on unstable surface (dense mattress), exercises in bipodal and unipodal support (right and left) with eyes open and closed, agility training with ball throwing.

- Station 2: Forward, backward and sideward march (right and left) with narrow base on unstable surface (foam mini beam), march alternating between floor and mini beam, agility training with ball throw.

- Station 3: Forward, backward, sideways and cross-legged march between the agility rings.

- Station 4: Side-to-side and front-to-back exercise on the proprioceptive lateral board with eyes open and closed, agility training with ball throw.

- Station 5: Forward, backward and sideward march between cones with narrowed base and circumferential path with full foot support, with heel support only, and with forefoot support only.

- Station 6: Exercises on proprioceptive disk with multidirectional shifts with eyes open and closed, agility training with ball throw.

- Station 7: Forward, backward and sideward march over agility barriers, agility training with ball throw.

The participants remained at each station for two minutes, with a thirty-second break between stations. After going through the seven stations, the course was repeated on the front, side, and back through all the stations continuously without breaks, with only a thirty-second break at the end of each circuit, until the proposed time of 30 minutes was completed.

The degree of difficulty was increased throughout the training via the speed of execution of the activities. In all the sessions, a researcher assisted each elderly woman on the execution and physical capacity of each participant was taken into consideration in relation to the execution of the activities. The exercises in the conventional training protocol were based on the literature [23-25].

The proprioceptive training based on virtual realities "exergames" was performed using the Xbox Kinect One videogame from Microsoft®®. This console uses motion sensor technology, the Kinect, which captures the movements of the players, they are sensitive to changes in direction, speed, and acceleration, thus allowing games to be controlled with body movement, without the need for any manual control [26].

The game used was Kinect Sports Rivals, which simulates six sports activities: jet ski racing, climbing, soccer, bowling, tennis and target shooting. The selection was guided by the analysis of the motor demands offered by the games. The exercises ranged from basic motor skills: squatting and lifting, jumping, turning, lumbar flexion, side-to-side and anterior-posterior displacement, and moving the arms in all directions, to more complex motor skills that stimulated coordination, balance, stability, and proprioception.

The more complex exercises consisted in extending an arm and flexing the contralateral leg associated with body thrust (climbing game); performing side-to-side displacement associated with flexion/extension and adduction/abduction movements of the upper limbs (tennis game); perform kicks, displacements, and body rotation (soccer game); perform hip and knee flexion, with trunk rotation and inclination (jet ski game); perform hip, knee, and ankle flexion with lower limbs in alternate position, associated with trunk inclination and shoulder flexion/extension movement (bowling game).

The selection process of the games was carried out during the pilot study, and in the main study only the games that were not difficult to play, that worked motor skills, and were more accepted by the elderly women were used. Thus, the game "target shooting" was excluded because it was repetitive, did not work motor skills in a satisfactory way, and presented a degree of difficulty that did not evolve gradually, which meant that it was not well accepted by the elderly women in the pilot study.

The training with exergames was carried out in a room with no objects that could interfere with the performance of the elderly women, in which the games were projected on the wall using an Epson PowerLite S8+ projector and a set of Multilaser© 60 WRms Sp088 speakers. The participants were accompanied by researchers, performed the activities in pairs, barefoot, and positioned in front of the Kinect sensor at a distance of three meters.

Three games were used per session and the duration of each game was 10 minutes, for a total of 30 minutes. The order of the games in each session was randomized, one game was replaced by another every six training sessions by random selection, allowing the participants to have contact at the end of the training with all five selected games.

Outcome assessment

For the evaluation of the study outcomes, a questionnaire composed of sociodemographic information, related to health, functionality, and fear of falling was used. The sociodemographic variables used were: age (complete years), marital status (with partner, without partner), education (illiterate, elementary, middle, higher education) and monthly family income in Brazillian Reais (BRL). For the categorization of family income the median was used, establishing the following categories (≤954.00 BRL, >954.00 BRL). The health-related variables were: Body Mass Index (BMI), presence of diagnosed diseases (yes, no), musculoskeletal pain in the last 7 days (yes, no), musculoskeletal pain in the last 12 months (yes, no), and medications (yes, no).

The functionality evaluation was composed of balance, functional mobility and functional physical performance of the lower limbs. For balance the Berg Balance Scale (BBS) translated and validated for the Brazilian population was used, which consists of functional clinical tests that evaluate the static and dynamic balance of individuals in daily activities. The BBS consists of 14 tasks, grouped into: transfers (tasks 1, 4 and 5), stationary trials (tasks 2, 3, 6 and 7), functional reach (task 8), rotational components (tasks 9, 10 and 11), and decreased base of support (task 12, 13 and 14). The scores used in each task were 0 for inability to perform activities up to 4 points for performing tasks independently, and the total scores ranged from 0 to 56 points, in which the maximum score corresponds to the best performance [27].

To assess functional mobility, the Time Up and Go Test (TUGT) was used, proposed [28], measured in seconds, evaluating the time spent by the participants to get up from a chair (45 cm high), walk a distance of three meters, turn around, walk towards the chair and sit down again. The TUGT is a sensitive and specific measure to identify elderly at risk of falling and is widely used to assess the functional mobility of this population. Independent individuals without balance alterations perform the test in ≤10 seconds (low fall risk); those who are dependent in basic transfers spend ≤20 seconds (medium fall risk). Individuals who need more than 20 seconds to perform the test are dependent in many activities of daily living and mobility (high risk of falls) [28].

To evaluate the functional physical performance of the lower limbs, we used the Short Physical Performance Battery (SPPB), which consists of a battery of tests proposed by Guralnik in 1994, and adapted and validated for the Brazilian population [29]. This instrument evaluates physical capacity, prioritizing tests of lower limb function, and is composed of three steps: balance, gait speed, and getting up and sitting down from a chair. For the balance test, the participants were instructed to maintain themselves in the bipedal posture in the following positions: feet together (side-by-side); one foot partially in front of the other (semi-tandem stand); and one foot in front of the other (tandem stand), maintaining themselves for 10 seconds in each position. For the walking speed test, a distance of 3 meters was adopted, and the participants were instructed to walk this distance at their usual pace, with two times recorded (round trip), and the shortest execution time was considered. The chair standing and sitting test was performed using a 44 cm chair, in which the participants stood up and sat down in the chair five consecutive times, without the aid of their upper limbs, and as fast as possible [29].

This instrument evaluates physical capacity, prioritizing tests of lower limb function, and is composed of three steps: balance, gait speed, and getting up and sitting down from a chair. For the balance test, the participants were instructed to maintain themselves in the bipedal posture in the following positions: feet together (side-by-side); one foot partially in front of the other (semi-tandem stand); and one foot in front of the other (tandem stand), maintaining themselves for 10 seconds in each position. For the walking speed test, a distance of 3 meters was adopted, the participants were instructed to walk this distance at their usual pace, with two times recorded (round trip), and the shortest execution time was considered. The chair standing and sitting test was performed using a 44 cm chair, in which the participants stood up and sat down in the chair five consecutive times, without the aid of their upper limbs, and as fast as possible [29].

The three steps are scored from 0 to 4, according to the time for each task. The total SPPB score was obtained by the sum of the scores in the balance tests, gait speed, and getting up from a chair five consecutive times, ranging from 0 (worst performance) to 12 points (best performance) [29].

The fear of falling was assessed by means of the Falls Efficacy Scale - International - Brazil (FES-I-BRAZIL), a version adapted and validated for the Brazilian population [30]. The FES-I-BRAZIL assesses the fear of falling in 16 activities of daily living (basic and instrumental) and socialization. The assessed items involve from tasks of low physical demand to tasks related to postural control, such as: cleaning the house, dressing and undressing, preparing meals, bathing, shopping, going up and down stairs and slopes, walking on slippery and uneven surfaces, visiting a friend or going to a social activity. Each question is scored on a scale of 1 to 4 points, with total values ranging from 16 points for individuals with no concern about falling to 64 points for individuals with extreme concern [30].

The evaluations were made in two moments: before training (T0) and after training (T1), by researchers who did not participate in the allocation process of the elderly women and had no contact with the treatment groups. For the CGT, the participants were evaluated and reassessed following the same period and place established for the intervention groups.

Data analysis

In the data analysis, absolute and relative frequencies were used for categorical data, and for quantitative data mean and standard deviation or median and interquartile range. To evaluate the homogeneous behavior of the quantitative variables (age and BMI) at baseline in the three groups (control, conventional, and exergame) the analysis of variance (ANOVA) and Kruskal-wallis tests were used, after checking the normality of the data using the Shapiro-Wilk test. Pearson's chi-square test and Fischer's exact test were used to compare the categorical variables (marital status, education, family income, presence of illness, pain in the past 7 days and 12 months, and medications) between groups at the beginning of the study.

In the inferential analysis (parametric or non-parametric) for the intragroup comparisons of baropodometric variables between two paired samples were performed using paired Student's t test or Wilcoxon test. Intergroup comparisons between three independent samples were performed by means of one-way analysis of variance (ANOVA) tests, and in case of statistical difference, Tukey's post-hoc test was used; or Kruskal-wallis, and in case of statistical difference, Dunn's post-hoc test was used.

In the case where the dependent variable (SPPB) showed a significant difference at baseline we conducted the analysis of covariance (ANCOVA), using the initial measurements of these variables (T0) as a covariate to control the effect of these variables on the difference in means (T1-T0) between the groups. After analysis, Sidak's post-hoc test was used.

The calculation of the effect size was performed for the comparisons between groups (i.e., comparisons of the differences between T0 and T1), and the partial eta^2 parameter (partia leta squared, η^2 partial) was adopted as an indicator of effect size, as recommended by Lakens [31] and Murphy et al. [32]. The interpretation of effect size followed the recommendations of Cohen [33], who suggests a small effect size when $\eta^2 = 0.01$, medium when $\eta^2 = 0.06$, and large when $\eta^2 = 0.14$.

The significance level adopted in all analyses was 5% ($\alpha = 0.05$), and the data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) for Windows, version 21.0.

Ethics and registration

This study was conducted in accordance with resolution no. 466/2012 of the National Health Council and approved by the Research Ethics Committee of the Universidade Estadual do Sudoeste da Bahia (Southwestern Bahia State University), under protocol no. 2.627.047, CAAE: 46887315.1.0000.0055. The study was registered in the Brazilian Registry of Clinical Trials (REBEC) database, registration number RBR-592yyp.

Results

Among the 50 elderly women who started participating in the research (17 control, 17 conventional, and 16 exergame), only 5 did not complete the study. Adherence to the intervention programs was 88.2% for the control and conventional groups, and 94.1% for the exergame group.

Regarding sociodemographic characteristics, it was observed that the mean age of the participants was 69.1 ± 6.0 years; 77.8% lived without a partner; 71.1% were illiterate or had elementary school education, 22.2% had high school education, and 6.7% had higher education. The majority (68.9%) declared a monthly family income ≤954.00 BRL.

According to the health-related variables, the average BMI was 26.6 ± 4.4 Kg/m^2; 82.2% reported the presence of diseases; 77.8% and 84.4% had musculoskeletal pain in the last 7 days and the last 12 months, respectively; and 95.6% used medications.

There were no statistically significant differences between the groups at baseline (control, conventional and exergame) regarding the distribution between: median age (p= 0.451, Kruskal-Wallis test); mean BMI (p=0.840, one-way ANOVA); marital status (p=0.550, chi-square test); education (p=0, 800, chi-square test); family income (p= 0.779, chi-square test); presence of diseases (p=1.000, chi-square test); musculoskeletal pain (p=0.280, chi-square test); use of medications (p=1.000, chi-square test), thus demonstrating homogeneity in the allocation of participants between the groups.

The analysis of mobility, balance, lower limb performance, and fear of falling in the control, conventional, and exergame groups at T0 showed that with the exception of SPPB, the variables showed no significant differences between the groups, indicating that the three groups had similar characteristics at study baseline (Table 1).

Table 1: Intergroup comparisons of functional mobility, balance, lower limb performance and initial fear of falling (T0) of the elderly women participating in the study.

Variable	Control	Conventional	Exergame	p-value
TUGT#	10.19 (3.16)	11.48 (2.75)	11.78 (2.71)	0.287
EEB*	55.00 (6.00)	54.00 (4.00)	55.00 (2.00)	0.384
SPPB#	11.47 (0.91)	10.13 (1.36)	10.33 (1.99)	0.008
FES-I-Brasil*	26.10 (17.00)	30.00 (12.00)	27.00 (13.00)	0.936

TUGT = Time Up and Go Test; BBS = Berg Balance Scale; SPPB = Short Physical Performance Battery; FES-I-Brazil = Falls Efficacy Scale International adapted to Brazil; # Mean (standard deviation), one-way ANOVA; * Median (interquartile range), Kruskall-Wallis test.

The comparisons between T0 and T1 in the control group showed a significant difference for the TUGT, indicating that, at the end of the period evaluated, the elderly women in this group presented significantly higher values in this variable, which characterized a worse performance in functional mobility (Table 2).

Table 2: Intragroup comparisons (T0 vs. T1) of functional mobility, balance, lower limb performance, and fear of falling for the control group of the elderly women participating in study.

Variable	T0 *(baseline)*	T1 (post-treatment)	p-value
TUGT#	10.19 (3.16)	11.36 (2.48)	0.021
EEB#	53.27 (3.41)	53.47 (2.80)	0.647
SPPB*	12.00 (1.00)	11.00 (2.00)	0.107
FES-I-Brazil*	26.10 (17.00)	32.00 (15.00)	0.072

TUGT = Time Up and Go Test; BBS = Berg Balance Scale; SPPB = Short Physical Performance Battery; FES-I-Brazil = Falls Efficacy Scale International adapted to Brazil; # Mean (standard deviation), Student's t test for paired samples; * Median (interquartile range), Wilcoxon test.

The comparisons between T0 and T1 in the conventional group showed a significant difference in all variables, indicating that, at the end of the treatment, the elderly women in this group presented significantly better values, which characterized an improvement in mobility, balance, lower limb performance, and less concern about the fear of falling (Table 3).

Table 3: Intragroup comparisons (T0 vs. T1) of functional mobility, balance, lower limb performance, and fear of falling for the conventional group of elderly women participating in study.

Variable	T0 (baseline)	T1 (post-treatment)	p-value
TUGT#	11.43 (2.71)	10.00 (3.06)	0.001
EEB#	54.00 (4.00)	56.00 (1.00)	0.001
SPPB*	10.13 (1.36)	11.40 (0.74)	<0.001
FES-I-Brazil*	28.53 (7.53)	24.73 (6.42)	0.001

TUGT = Time Up and Go Test; BBS = Berg Balance Scale; SPPB = Short Physical Performance Battery; FES-I-Brazil = Falls Efficacy Scale International adapted to Brazil; # Mean (standard deviation), Student's t test for paired samples; * Median (interquartile range), Wilcoxon test.

The comparisons between T0 and T1 in the exergame group showed a difference for BBS, SPPB, and FES-I-Brazil, indicating that, at the end of the treatment, the elderly women in this group presented significantly better values for these variables, which characterized an improvement in balance, lower limb performance, and less concern about the fear of falling (Table 4).

Table 4: Intragroup comparisons (T0 vs. T1) of functional mobility, balance, lower limb performance, and fear of falling for the exergame group of the elderly women participating in the study.

Variable	T0 (baseline)	T1 (post-treatment)	p-value
TUGT#	11.78 (2.71)	11.02 (1.84)	0.220
EEB#	55.00 (2.00)	56.00 (1.00)	0.011
SPPB*	11.00 (2.00)	12.00 (0.00)	0.003
FES-I-Brazil*	27.00 (13.00)	22.00 (10.00)	0.003

TUGT = Time Up and Go Test; BBS = Berg Balance Scale; SPPB = Short Physical Performance Battery; FES-I-Brazil = Falls Efficacy Scale International adapted to Brazil; # Mean (standard deviation), Student's t test for paired samples; * Median (interquartile range), Wilcoxon test.

The comparative analysis of changes in mobility, balance, lower limb performance, and fear of falling showed significant differences between the groups. For the TUGT, SPPB, and FES-I-Brazil variables there was a better effect of conventional training and exergame when compared to the control group; while for the BBS variable, there was a better effect of conventional training compared to the control group.

Among all the variables studied, no significant differences were observed between the conventional and exergame groups, indicating a similar effect of the two trainings. Regarding the effect size, the results indicate an effect classified as large for all variables studied (0.185 - 0.348) (Table 5).

Table 5: Intergroup comparisons of changes (T1-T0) and effect size of functional mobility, balance, lower limb performance, and fear of falling of the elderly female study participants. Jequié, Bahia, 2019.

Variable	Control	Conventional	Exergame	p-value	η^2 partial
TUGT #	1.17 (1.74) ^{a}	-1.37 (1.20) ^{b}	-0.75 (2.27) ^{b}	0.001	0.281
SPPB +	-0.03 (1.44) ^{a}	0.91 (1.39) ^{b}	1.18 (1.37) ^{b}	0.001	0.348
EEB *	0.00 (2.00) ^{a}	1.00 (3.00) ^{b}	1.00 (2.00) ^{ab}	0.009	0.185
FES-I-Brazil*	0.90 (2.00) ^{a}	-3.00 (5.00) ^{b}	-2.00 (6.00) ^{b}	<0.001	0.334

TUGT = Time Up and Go Test; BBS = Berg Balance Scale; SPPB = Short Physical Performance Battery; FES-I-Brazil = Falls Efficacy Scale International adapted to Brazil; # Difference of means T1-T0 (standard deviation), one-way ANOVA, Tukey post-hoc; + Difference of means T1-T0 (standard deviation), ANCOVA, Sidak's Post-hoc; * Difference of medians T1-T0 (interquartile range), Kruskal-wallis test, Dunn's Post-hoc; a,b Different letters on the lines indicate that the difference between groups was statistically significant ($p \leq 0.05$); partial η^2 = effect size.

Discussion

The results of this study showed that the group of elderly women who received conventional proprioceptive training improved mobility, balance, and physical performance, and reduced the concern with the fear of falling. The group that underwent training with virtual reality showed improvement in all the outcomes of the study, with the exception of functional mobility. The control group did not show improvement in any of the study outcomes, and mobility showed a statistically significant worsening after the period studied.

The positive effects of the training sessions proposed in this study are probably due to the characteristics of the proprioceptive activities developed. The activities involved integrated movements in several dimensions, including joint acceleration, strength, neuromuscular efficiency, the adaptation of several components of the nervous system, allowing gains in proprioception, strength, and muscular endurance, as well as flexibility, motor coordination, and balance [34-36].

Some authors have defended in their studies the importance of specific training to improve functionality and prevent falls in the elderly [36-39]. The trainings approached by the aforementioned authors were similar to the present study and had similar results. However, differently from those studies, which compared only two groups and approached a smaller number of outcomes, the present study, besides assessing several outcomes at the same time, such as mobility, balance, functional performance and fear of falling, compared three groups, being two training modalities and a control group.

The effects of a training with conventional multisensorial exercises on balance, mobility and physical performance of elderly people, observed, at the end of the intervention period, a shorter time to perform the TUGT and a better physical performance of the lower limbs evaluated by the SPPB [11]. According to some studies, the better performance on the TUGT obtained by the conventional training group reflects better conditions to perform daily activities, such as standing up, sitting down, walking, among others; and consequently, a lower probability of falls, institutionalization and even death in elderly individuals [40,41].

The improvement in the functional performance of the lower limbs obtained by the group who did conventional training, in the present study, can be explained by the sensory and musculoskeletal stimuli offered by the sensory-motor training of this modality. These exercises are performed with alternating speeds, thus stimulating different types of muscle fibers, among them type II, which help improve speed when performing the movement of sitting down and getting up from a chair [11].

Another clinical trial analyzed balance and the risk of falls in two groups of elderly subjects, one participating in a conventional balance circuit and the other as a control. The results showed improvements in balance and a reduction in the risk of falls in the intervention group in relation to the control group [37]. A 12-month randomized clinical trial that compared the effects of a conventional balance program with the control group in elderly women observed that only the group that received conventional training improved functional balance, increasing on average 5 points in the BBS score, and reduced the number of falls [42]. However, in both studies, the conventional training was not compared with another type of intervention, which makes it impossible to generalize the results and compare the effects with other interventions.

Another study that analyzed the effects of a conventional multi-sensory proprioceptive exercise program on the functionality of the elderly was, in which they observed a significant improvement in balance (BBS) and functional mobility (TUGT) of community-dwelling elderly people [43]. It is worth noting that the results were not compared with another type of training or with a control group, which makes it impossible to compare the effects with another intervention.

The effects of a conventional balance exercise circuit on several functional variables in elderly women showed the program promoting improvements in balance and functional performance of elderly women compared to the control group. In addition, the high compliance of the participants with the training illustrates the importance of programs that incorporate socialization and exercises that are similar to the activities of daily living [38]. However, conventional training was not compared with another intervention modality.

The training strategies adopted for the proper functioning of the center of mass within the base of support of the elderly in different positions, maintenance of proper body alignment, maintenance of gaze stability, adequate anticipatory and reactive reactions to external disturbances, functional exercises and with changes in support surfaces, activate proprioceptive impulses integrated to sensory-motor centers that automatically control the adjustments in the contraction of postural muscles, providing improvement in postural balance and functionality to the elderly [44,45]. In the present study, the conventional training program adopted used similar techniques, which helped achieve the objectives.

Regarding training using virtual reality, the positive effects obtained in the functionality and fear of falling of the elderly women in this study can be explained by the characteristics made available by this resource, such as a higher number of repetitions, high variability, auditory and visual feedback, besides the complexity of the virtual tasks with high cognitive and motor demands, which helps to promote a higher integration of this type of skills, contributing to a greater independence in the daily life of these individuals [46-48].

In another randomized clinical trial that investigated the effect of the Xbox Kinect on elderly individuals, it was concluded that the group that used virtual reality showed positive results in the improvement of gait, lower limb muscle strength, and balance when compared to the control group that did not perform any activity [14]. Another study that evaluated the effects of training with Xbox Kinect [49] also observed that the group submitted to virtual reality significantly increased the BBS score when compared to the control group. However, the results of these studies were not compared with another intervention, which makes it impossible to generalize the results and compare the effects with a conventional intervention.

Another virtual reality-based physical exercises protocol, observed an improvement in mobility and physical performance in the elderly. The authors believe that these improvements are attributed to neurobiological mechanisms that may have improved efficiency in cognitive and spatial navigation skills [50]. It was also observed that regarding fear of falling, the findings were not significant, but the exergame group obtained better scores compared to the control group, showing a positive outlook.

The concern with the fear of falling in elderly people exponentially limits the performance of habitual tasks that demand multiple interactions of the sensory-motor system [4]. Elderly individuals with functional capacity, balance and gait alterations end up having impairments in the execution of a safe and effective ambulation and compromise the self-confidence of these individuals in avoiding falls, generating a basis for the construction of the fear of falling [5]. Although few studies have approached the effects of specific physical therapy training on the fear of falling in elderly people, the present study showed that not only the conventional and virtual training had positive effects on the elderly females' fear of falling, but they also contributed to the improvement of factors related to the fear of falling, such as the physical performance of the lower limbs, mobility, and balance.

Regarding the comparisons of the intergroup effects on the outcomes studied, the results of the present study showed that there was a better effect of conventional training and exergame when compared to the control group, but no significant differences between the intervention groups.

When comparing the effects of balance exercises with virtual reality and conventional balance exercises in the elderly, they showed that in both groups, the scores for balance (BBS) and mobility (TUGT) improved significantly as time, but the changes were similar between the two groups [51]. Regarding fear of falling (FES-I), there were no changes after the treatment period in both trainings. In the study that compared the effects of virtual reality through the Xbox Kinect versus conventional physical therapy in the elderly, they observed that both interventions had positive effects on balance, gait, and cardiorespiratory fitness of the elderly, but there were no significant differences between the training modalities [39]. It is worth mentioning that, unlike the present study, in both of the aforementioned studies the intervention groups were not compared with a passive control group, i.e., that did not receive any type of intervention.

The results of the present study showed that both the conventional training and the training with virtual reality provided improvement in the functionality and fear of falling of the elderly women. The efficacy of the training shown in this study proves that the improvement of elderly women's functionality can be achieved without costly and easily accessible resources as in the case of conventional training; and that virtual reality has become an available resource, providing, through an innovative therapy, benefits to the functionality of elderly women because of the playfulness and various possibilities of tasks to be performed through the proposed games.

It is important to emphasize the need for follow-up studies in order to verify the duration of the effects of the interventions after their completion.

Conclusion

The results of this study showed that conventional proprioceptive training and virtual reality-based training can promote improved functionality and reduced fear-of-fall concerns in elderly women; however, when comparing the intergroup effects, there were no significant differences between the trainings with respect to the outcomes studied.

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