Wii-Workouts on Chronic Pain, Physical Capabilities and Mood of Older Women: A Randomized Controlled Double Blind Trial

Renato Sobral Monteiro-Junior; Cíntia Pereira de Souza; Eduardo Lattari; Nuno Barbosa Ferreira Rocha; Gioia Mura; Sérgio Machado; Elirez Bezerra da Silva

Abstract

Chronic Low Back Pain (CLBP) is a public health problem and older women have higher incidence of this symptom, which affect body balance, functional capacity and behavior. The purpose of this study was to verifying the effect of exercises with Nintendo Wii on CLBP, functional capacity and mood of elderly. Thirty older women (68 ± 4 years; 68 ± 12 kg; 154 ± 5 cm) with CLBP participated in this study. Elderly individuals were divided into a Control Exercise Group (n = 14) and an Experimental Wii Group (n = 16). Control Exercise Group did strength exercises and core training, while Experimental Wii Group did ones additionally to exercises with Wii. CLBP, balance, functional capacity and mood were assessed pre and post training by the numeric pain scale, Wii Balance Board, sit to stand test and Profile of Mood States, respectively. Training lasted eight weeks and sessions were performed three times weekly. MANOVA 2 x 2 showed no interaction on pain, siting, stand-up and mood ($P = 0.53$). However, there was significant difference within groups ($P = 0.0001$). ANOVA 2 x 2 showed no interaction for each variable ($P > 0.05$). However, there were significant differences within groups in these variables ($P < 0.05$). Tukey's post-hoc test showed significant difference in pain on both groups ($P = 0.0001$). Wilcoxon and Mann-Whitney tests identified no significant differences on balance ($P > 0.01$). Capacity to Sit improved only in Experimental Wii Group ($P = 0.04$). In conclusion, physical exercises with Nintendo Wii Fit Plus additional to strength and core training were effective only for sitting capacity, but effect size was small.

Keywords

Aging, lumbago, video games, mood disorders, exergames, rehabilitation.

INTRODUCTION

Neuropsychological aspects influence several types of pain-related disorders [1, 2]. Moreover, aging may cause a lot of tissue damage resulting in symptoms like pain [3]. Chronic pain is common in elderly people and it is related to musculoskeletal diseases [4] and/or depressive symptoms and mood disorders [5]. Chronic low back pain (CLBP) is a common disorder in aging and it is considered a public health problem [6, 7]. However, this symptom is usually treated with physiotherapy and medication. New strategies of treatment for people with CLBP have been widely discussed. CLBP could be associated with anatomic abnormalities and/or motion dysfunction [8], herniation and others. Motion dysfunction is related to weakness of deep muscles of trunk or delay in their activation [9]. This could result a compensatory muscle activity and pain [8]. Injuries in the intervertebral disc result in excessive compression on spine that is transmitted to specific area of the discs [10]. In lumbar spine, this process could press nervous root and consequently cause sciatic pain [11]. Around 85% of CLBP cases have nonspecific origin [12]. This symptom could provoke many other problems, such as body imbalance [13], which worsen in accordance with pain intensity [14] beyond resulting in decrease of functionality [7].

In Brazil, this problem is one of the major causes responsible for impairments and removal on work [6].

Moreover, aging and physical inactivity lead to decreased in physical capacities [15-17] that result in risk of falls [18]. The reduction in functional abilities decreases functional autonomy [17] and could result in development of depressive symptoms [19] and other emotional disorders. Furthermore, aging could reduce functional capabilities like sit and standup [20], which represent the minimum amount of strength, balance and flexibility needed for health [21]. Thus, elderly tend to develop CLBP [6], contributing to a reduction in functionality [22]. Physical exercise is often used to reduce CLBP [8] and deficits due to aging [16, 18, 23]. The innovative method that has been used to improve physical capacities, sensorimotor activity and decrease in pain by hypnotic mechanism is physical training with virtual reality [24, 25]. The use of virtual reality in exercise aims to give extrinsic visual feedback to individual during physical task and its possibility to self-adjusts of motion [24], posture and balance [26]. Moreover, physical exercise with virtual reality can be considered a dual-task because it offers motor and cognitive stimulus [27] and it maybe decreases perceived pain. To date the scientific literature still not elucidated the main effects of physical training with virtual reality on chronic pain, functional responses and neuropsychological variables in the elderly. It is important to highlight that virtual exercises without supervision of health professionals could result in several injuries [28, 29]. Therefore, the purpose of this study was to verify the effectiveness of strength exercise additional to Nintendo WiiTM on chronic low back pain, functional capacity and mood in older women.

MATERIALS AND METHODS

Design of Study Randomized double blind controlled trial. Fifty-five older women were recruited to participate of the study, which was conducted at Fisioprime Clinical of Physiotherapy (i.e., a center of rehabilitation). Participants were randomly divided into two groups: Control Exercise Group (CEG) and Experimental Wii Group (EWG). CEG performed strength exercise (closed and open chain kinetic and core exercises) while WEG performed the same exercises but eight Wii Fit Plus workouts were added. CLBP, balance, functional capacity and mood were assessed before and after intervention. The evaluation process was blinded (Fig. 1). Training lasted eight weeks, with three weekly sessions lasting 90 minutes each. Protocols of this type of exercise training (with virtual reality) are still not well established, because the outcomes of subjects are unclear (for review see reference 43).

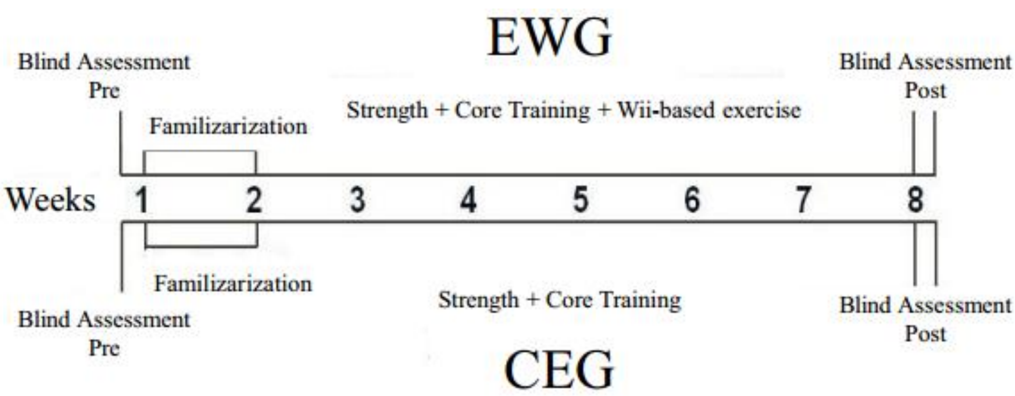

Fig. (1). Experimental design.

Sample Size

Sample size was estimated using G Power. Effect size (ES) was calculated with basis on α value and power of the test. With ES used (1.1), α (0.05) and power of test (0.80), the sample size was estimated reaching 30 subjects. ES was estimated in accordance to data acquired in a previous study [30], chosen due to methodological design (i.e., doubleblind, randomized controlled).

Participants

Thirty-four older women participated in this study (68 ± 4 years; 68 ± 12 kg; 154 ± 5 cm) with non-specific CLBP. Participants selection met eligibility criteria as follow: a) CLBP; b) individuals non-participant in systematic exercise program; and exclusion criteria: a) people without medical recommendation (Physical Activity Readiness Questionnaire (PAR-Q) [56]; b) patients that underwent spine surgery; c) patients with cancer; d) acute musculoskeletal injuries in lower limbs; e) neurological illnesses; and f) vestibular noncontrolled disorders. Participants were allocated in two parallel groups (CEG and EWG). Random numbers were generated by an independent researcher through an Excel spreadsheet. The groups were homogeneous before intervention (P>0.05).

Ethics Procedure

All participants signed the consent form to participate in this study. The rules of Ministry of Health were respected in accordance to resolution 466/96. The present study was approved by the Ethics Committee of the Gama Filho University (155/2011 (CAAE 0120.0.312.000-11)) and registered at Clinical Trials Registration (NCT01503203).

Control Exercise Group

CEG group was submitted to an exercise program with core training and strength training. Strength training occurred immediately after core exercises. In core exercises the postures adopted by subjects lasted 15-30 seconds or in according with the capacity of each one. Were adopted 10 – 15 seconds between postures (i.e., bridges) and each ones were performed three times (Table 1). The strength training emphasized lower limbs and was applied in order of appearance shown in Table 1. In each exercise, 10 repetitions were performed and the subjects were asked to do each exercise three times (i.e., sequential method), with sufficient intervals for changing the machines. The prescribed load of exercise was moderate (5-6; 0 to 10 values) according to rated perceived exertion [31]. We choose this type of control intensity to maintain physical integrity of the participants, because maximal or submaximal tests could cause increase in pain or injury. Workload was increased from 5 to 10% weekly in accordance with reduction of pain. The intervention lasted eight weeks and sessions were performed three times a week. In fact, there was no consensus about this type of intervention because there are a few studies on this topic (i.e., exergames for elderly). Moreover, these studies show heterogeneity in their methodologies of training. Therefore, we based on Position Stand about exercise prescription for older adults published by American College of Sports Medicine [31].

Table 1. Description of core training and strength exercises.

Core Training	Description
Core training - Bridge 1	In proned position individual should sustaning body on forearm and knees mantaining the trunk elevated.
Core training - Bridge 2	In lateral (horizontal) position individual should sustaning body on forearm and knees (flexed) mantaining the trunk elevated.
Core training - Bridge 3	In supined position individual should sustaning body on thoracic region and feet. Knee should be flexed and pélvis out of ground maintaining trunk elevated.
Strength Exercises	**Description**
Squat	Individual should perform a maximum squat (confortably) with paralel feet.
Lunge	Individual should perform a step and squat maintaining a upright posture.
Chair abductor	Individual should perform hips abduction seated on a chair bilaterally.
Chair adductor	Individual should perform hips addu ction seated on a chair bilaterally.
Leg curl (chair)	Individual should perform leg curl seated on a chair bilaterally.
Knee extension (chair)	Individual should perform leg extension seated on a chair bilaterally.
Unilateral plantar flexion	In ortostatic position individual should perform a unilateral plantar flexion.

Experimental Wii Group

This group received the same intervention that CEG plus 30 minutes of virtual physical training (eight exercises) using Nintendo Wii-motion and Wii Balance Board. Games and activities are described in Table 2. Three initial sessions were performed as familiarization. During familiarization the participants were allowed to play games until two times. After the fourth session, the participants had only one attempt for each game. It was allowed verbal stimulus during activities. To eliminate adverse events (e.g., vertigo) rest periods were administered between games (1-2 minutes), in which individuals sat. The intervention had same duration of that performed by the CEG group. To minimize bias (EWG trained with Wii Balance Board while CEG did not), CEG performed balance tests on Wii Balance Board weekly.

Table 2. Activities with wii fit plus.

Order/Activities	Game	Description
1º-Yoga	Chair	Maintaining plantar, knees and hip flexion (isometric squat). In screen individual should observes and maintains center of pressure into circle of reference.
2º-Balance Games	Tightrope walk	Walking on tightrope between two buildings. Individual should maintain balance on médio-lateral axis.
	Ski slalom	Skiing passing between flags. Individual should maintain balance on both axis.
	Balance buble	Navigating by river with no touch margins. Individual should maintain balance on both axis.
	Table tilt	Hit the balls in the holes moving a table. Individual should maintain balance on both axis.
3º-Strength	Sideways	Individual should perform unilateral hip abduction maintaing Center of pressure into circle of reference.
	Rowing squat	Individual should perform squat and rowing with paralel feet maintaining uprigth posture. In screen it should control centre of pressure with heels.
	Lunge	Unilateral squat. One foot on WBB and other in the ground (back). Individual should pressing greater force in the front leg.

Pain

Pain was evaluated by numeric scale of pain [32] ranging from 0 to10 points, where 0 and 10 mean without pain and worse pain, respectively. This tool was used pre and post intervention and assessment was blinded.

Balance

Balance was measured through Wii Balance Board (WBB) [33] (Nintendo®, Kyoto, Japan). This plate has 45 cm x 26,5 cm of surface. Elliptical area (EA) of displacement of center of pressure (COP) (cm2) was measured. We performed reliability tests in this study (i.e., within and between days) and our results were reliable ($R = 0.91$; $P < 0.05$). Participants were asked to maintain orthostatic position and remain at standing quiet posture as possible and arms along the body. Feet were positioning apart (in line of shoulders). Feet position was recorded for subsequent analysis (pre – post intervention). This procedure had the purpose of minimize bias because of different positions. For this purpose we used a mold of paper for each person. People performed tests with eyes open and close. The participants were asked to keep their gaze on a fixed point at the wall at the distance around two meters. All evaluations were performed by a blind assessor. Signal was obtained by interface between computer and WBB by using the software Labview 8.5 (National Instruments, Texas, EUA). Communication between WBB and computer was established by Bluetooth device. Signal was obtained at 40 Hz of frequency and we used a 12 Hz low-pass filter. WBB calibration was similar to that obtained in a previous study [33]. Three tests were recorded.

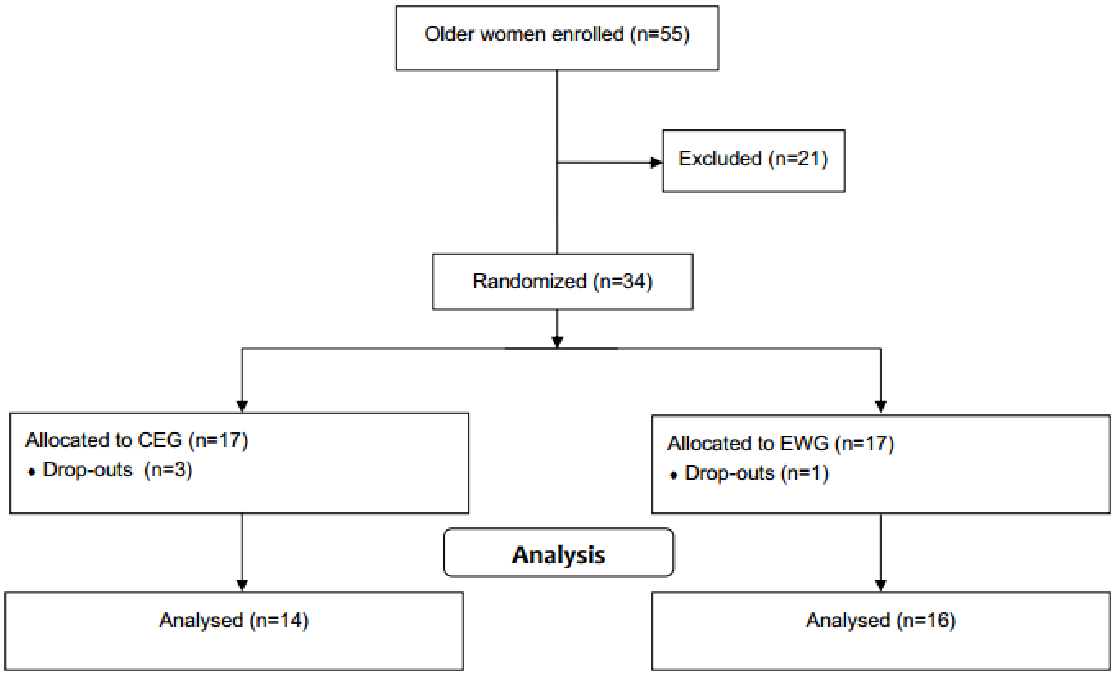

Fig. (2). Fluxogram of recruitment of elderly.

Functional Autonomy

Sit-to-stand test was used to evaluate the specific ability for sit-to-stand from the floor [21]. The score is measured according to imbalances and quantity of support that subjects use during action for sit and stand. Each person start test with five points (maximum score), but for every imbalance presented and for any support used should be discounted a half point or one point, respectively. This evaluation was blinded.

Mood

We used the Profile of Mood States (POMS) to evaluate the total mood disturbance. Each question answered should represent how the person has been feeling in the past seven days. Score of each question range 0-4 points. This scale has six domains: tension, depression, fatigue, confusion, hostility and vigor. We used a Portuguese version of scale [34].

Blind

Process All evaluations were blinded and assessed by a physiotherapist (C. P.) trained before to start the study twice a week during three weeks in all proceedings. Statistical analysis was blinded and performed by another physiotherapist (E.S.) that received a sheet containing EWG and CEG encoded data. This researcher did not participate in screening, evaluation or intervention. Therefore, this study was considered a double-blind research.

Statistical Analysis

Results of data analysis are presented as mean ± standard deviation. Data of pain, functional autonomy and mood attended assumptions for parametric analysis, and therefore, the hypothesis was tested by MANOVA 2 x 2 with repeated measures. Such analysis was used because variables are related and type one error can be reduced. When MANOVA showed significance difference we used ANOVA 2 x 2 with repeated measures and Tukey's post-hoc analysis for each variable. Statistical significance was assumed at $P \leq 0,05$. Balance data does not respected assumptions for parametric analysis. Therefore, comparisons within and between groups were tested by Wilcoxon e Mann-Whitney tests, respectively. However was used Bonferroni adjusted for reducing type one error [35]. Statistical significance was assumed at $P \leq 0,01$. All data were analyzed with Statistica 6.0 (StatSoft, EUA). These analyses were blinded. To verify clinical effects of interventions we used effect size (ES) [36] within and between groups.

RESULTS

Twenty-one out of 55 recruited subjects did not meet inclusion criteria. Therefore, only 34 older women (62%) were selected for this experiment. They were randomly allocated at rate of 50% at CEG (n = 17) and 50% at EWG (n = 17). During the intervention four participants (12%) interrupted training for personal reasons. Thereby, only 30 participants finished program and these data were included for analysis (CEG, n = 14; EWG, n = 16) (Fig. 2). MANOVA 2 x 2 with repeated measures considering pain, functional capacity to sit and stand and mood presented for interaction $F = 0,86$; $P = 0,53$ and within group $F = 16,84$; $P = 0,0001$. ANOVA 2 x 2 with repeated measures for each variable above showed for interaction $F = 0,08$; $P = 0,79$, $F = 1,58$; $P = 0,22$, $F = 0,92$; $P = 0,35$; $F = 0,004$; $P = 0,95$. Within groups analysis showed significant results ($F = 74,42$; $P = 0,0001$, $F = 7,17$; $P = 0,013$, $F = 5,35$; $P = 0,03$ and $F = 8,85$; $P = 0,007$, respectively). Post hoc of Tukey identified significant difference for pain on both groups (CEG:, $P = 0,0001$; EWG: $P = 0,0001$) and functional capacity for sit only in EWG ($P = 0,04$) (Table 1, Figs. 3, 4). Wilcoxon and Mann-Whitney after Bonferroni correction did not identify significant differences within or between groups for balance ($P > 0,01$) (Tables 3 and 4).

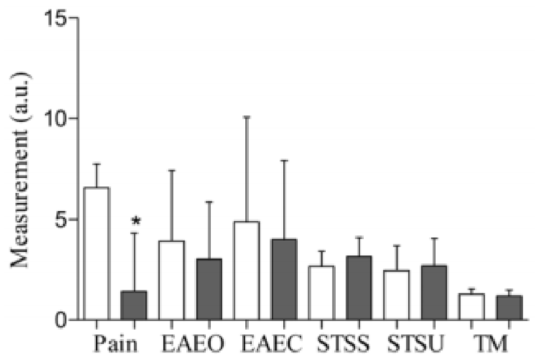

Fig. (3). Exercise Control Group results. White bars are pre-treatment and gray bars are post-treatment. EAEO, eliptical area with eyes open; EAEC, eliptical area with eyes closed; STSS, sit-to-stand (sit); STSU, sit-to-stand (up); TM, total mood. Mood was divide by 100 for better graphic view. *P<0.05 within groups. a. u., arbitrary unit.

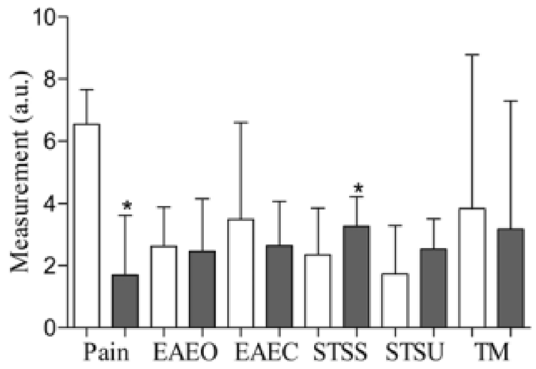

Fig. (4). Experimental Wii Group results. White bars are pre-treatment and gray bars are post-treatment. EAEO, eliptical area with eyes open; EAEC, eliptical area with eyes closed; STSS, sit-to-stand (sit); STSU, sit-to-stand (up); TM, total mood. Mood was divide by 100 for better graphic view. *P<0.05 within groups. a. u., arbitrary unit..

Table 3. Comparisons within/between groups: pain, balance, functional capacity and mood.

Variable	CEG		P	EWG		P	Int
	Pre (n = 12)	Post (n = 12)		Pre (n = 13)	Post (n = 13)		
Pain	6.6 ± 1.2	1.4 ± 2.9	< 0.01	6.5 ± 1.1	1.7 ± 1.9	< 0.01	ns
Bal (cm^2)	3.9 ± 3.5	3.0 ± 2.8	ns	2.6 ± 1.3	2.5 ± 1.7	ns	ns
FA Sit	2.8 ± 1.0	3.2 ± 0.9	ns	2.3 ± 1.5	3.3 ± 0.9	0.04	ns
FA S.up	2.5 ± 1.2	2.8 ± 1.3	ns	1.7 ± 1.6	2.5 ± 1.0	ns	ns
TM	135.1 ± 27.7	114.7 ± 29.1	ns	125.0 ± 24.9	105.5 ± 15.4	ns	ns

Int – Interaction; Bal – Balance; FA – Functional Capacity (S) Sit and (S.up) Stand Up; TM – Total Mood; ns – Non-Significant. CEG, Control Exercise Group; EWG, Experimental Wii Group.

Table 4. Effect Size (ES) within and between groups.

Variable	CEG	EWG	ES Between
	ES Within	ES Within	
Pain	4.3	4.4	0.1
Bal (cm^2)	0.3	0.1	0.2
FA Sit	0.3	0.7	0.1
FA S.up	0.3	0.5	0.3
TM	0.7	0.8	0.4

FA – Functional Capacity (S) Sit and (S.up) Stand Up; TM – Total Mood. CEG, Control Exercise Group; EWG, Experimental Wii Group.

DISCUSSION

The present study was based on the hypothesis that people with CLBP would reduce pain intensity, increase balance and functional capacity and would improve mood after exercise training in addition of virtual reality game [13, 14, 19, 37]. Graphically this appear be true but without significant difference between groups.

Our design compared two homogeneous groups of older women performing a physical activity intervention, in which the only difference between groups was eight virtual reality exercises, because strength and core exercises were common to both groups. Thereby, if we had identified differences between groups for one variable, this result would be due to virtual exercises.

After 24 sessions of core and strength training (CEG) and same intervention plus Wii exercises (EWG), both groups showed similar perceived pain post-training (1,4 ± 2,9 and 1,7 ± 1,9, respectively). For this comparison ANOVA 2 x 2 showed F = 0.08 and P = 0.79 for interaction. We hypothesized that EWG would decrease perceived pain because cognitive stimulus and distraction augmented by virtual reality might enhance threshold of acute, chronic or induced pain [38-41]. However, this was not observed. Possibly core and strength exercises had an effect with so high magnitude and maybe virtual exercises had a masked small effect. Core training was common to both groups and it was performed with three stabilizations (bridges) at prone, supine and lateral position of trunk. This training was consisted of three sets of 15-30 seconds with a frequency of three times a week during eight weeks. Core training is a good method for strengthening deep muscles of trunk and it is related to reduced pain [42]. Possibly this method of training was determining in the reduction of pain and it could had resulted in less perceived intensity of pain in both groups. Quantity of core training applied in both groups decreased pain around five points (pre ~ 6 points and post ~ 1 point in both groups). It is possible that floor effect had occurred because the lower number of scale is zero. Therefore, it could have decreased the effect of exercises with virtual reality. The majority of the studies that used exercises with virtual reality showed significant changes in balance in patients with neuromotor deficit [43]. However, there are limited informations about this intervention in individuals without neurological deficits but with reduced sensory capacity (e.g., aging or presence of pain). With reduction of pain in both groups, we hypothesized that the intervention would have improved the balance within and/or between groups because pain influences postural stability [13]. Moreover, it could be hypothesized that the eight additional exercises performed by EWG for balance would have improved postural stability in comparison with CEG, but it has not occurred. The fact that balance is modulated by multisensory pathways [13, 18], and that somatosensory deficits provoked by low back pain could influence the control of stability, a reorganization may adjust it by other sensory systems (e.g., visual system). It could be explained because individuals with CLBP have higher dependence from the visual system to control postural stability [13, 44]. Such compensation may be caused by a chronic adaptation of neurosensory pathways, where somatosensory system exerts influence on balance regulation despite the decrease in pain. The ability of proprioceptive system to send information to cortex may have been reduced by a long-time low activation of this pathway. Rauschecker et al. [45] observed that cats with visual deprivation showed neurosensory compensation. Liepert et al. [46] showed that such compensation mechanism occurs in humans with brain damage. Therefore, in the present study, both groups (CEG and EWG) did not showed improvement in balance, besides reduction in pain. Another possibility that explains our finding may be based on the relation between duration of intervention and type of virtual reality system used. Generally, we make decision for navigate in the space according to an egocentric reference system [23, 47, 48]. Optic flow (i.e., information that is processed in visual cortex based on our own body orientation) is received and adjusted according to intrinsic feedback. However, the majority of Wii Fit games are based on an allocentric reference system, where positioning sense is represented by an object of reference [23]. In this study, the fact that elderly women considered an avatar as reference (i.e., as their own body representation) may have caused a conflict in the visual processing of information and therefore may have required them to adapt based on the new reference system. Sensory conflicts may occur in acute way in different environments of virtual stimulations and they are associated to increase in body sway [49]. In addition, the volume of training administered in the present study may have reduced the possibility of the participants to modifying the body stability control (i.e., dose-response relationship). A similar study [50] conduced with 10 weeks of Wii-training, showed that elderlies did not improve body balance. According to the literature, most of longitudinal experiments with virtual reality exercises that showed improvement in physical capacities, such as balance and motor function, adopted volumes of intervention between 2-4 weeks [26, 30, 51-54]. Most of these studies were conducted with people with neurological disorders [30, 51-54]. It could explain expressive adaptations of these people by neuroplasticity mechanism [55]. On the other hand, as our study did not measure multi-sensory processing responses our arguments are only hypothetical and need future investigations. We also hypothesized that functional capacity for sit to stand would improve in the two groups because both reduced pain. However, EWG improved functional capacity for sit. It is possible because three exercises (i.e., Chair, Rowing Squat and Lunge) involved muscles and joints specific for the sit to stand movement. For instance, specific positioning in the Chair exercise (isometric knee and hip flexion for approximately 30 seconds) improved sitting capacity. These results allow to hypothesize that Wii Fit Plus might be a good training with specific motor elements to enhance the functional capacity of elderly with CLBP, beyond the fact that the literature has shown functional improvements only in elderly people with neurological injuries [43]. We do not found associations among responses (e.g., decrease of pain and improvement of balance; improvement of balance and functional capacity; and decrease of pain and improvement of mood). A reduction in pain would improve the affective state [32] but it was not significantly different between groups and this may be associated with problems in self-assessment. It is important to highlight a greater adhesion into EWG (92%) than CEG (75%). Entertainment provided by exercises with Wii Fit Plus perhaps had increased pleasure, and thus, promoted greater adherence rate in EWG. It should be considered in any type of intervention since to be effective it is need continuity.

CONCLUSION

Physical exercises with Nintendo Wii Fit Plus in addition with strength and core training was effective only for sitting capacity (i.e., functional capacity) in elderly women with chronic low back pain. Both types of interventions were effective to decrease pain but did not have effects on balance and mood. This study shows a perspective of a new training for older women.

LIST OF ABBREVIATIONS

CEG = Control Exercise Group

CLBP = Chronic low back pain

COP = center of pressure

EA = Elliptical area

EWG = Experimental Wii Group

POMS = Profile of Mood States

WBB = Wii Balance Board

REFERENCES

[1] Jacobs R. Psychological aspects of chronic pain. J Natl Med Assoc 1983; 754: 387-91.

[2] Swanson DW. Chronic pain as a third pathologic emotion. Am J Psychiatry 1984; 1412: 210-4.

[3] Ract I, Meadeb JM, Mercy G, Cueff F, Husson JL, Guillin R. A review of the value of MRI signs in low back pain. Diagn Interv Imaging 2015; 96(3): 239-49.

[4] Luttosch F, Baerwald C. Schmerztherapie bei älteren Patienten. Zeitschrift für Rheumatologie. 2014; 73(3): 233-43.

[5] Bergander B, Erdur L, Kallenbach-Dermutz B, Deter HC. Younger and older chronic somatoform pain patients in psycho-diagnostics, physician-patient relationship and treatment outcome. Biopsychosoc Med 2013; 71: 4.

[6] Filho NM. Invalidez por dor nas costas entre segurados da Previdência Social do Brasil. Rev Saúde Pública 2011; 45(3): 494- 502.

[7] BenDebba M, Torgerson WS, Boyd RJ, et al. Persistent low back pain and sciatica in the United States: treatment outcomes. J Spinal Disord Tech 2002; 15(1): 2-15.

[8] Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. Curr Sports Med Rep 2008; 7(1): 39-44.

[9] Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain. A motor control evaluation of transversus abdominis. Spine 1996; 21(22): 2640-50.

[10] Vialle LR, Vialle EN, Henao JES, Giraldo G. Lumbar disc herniation. Rev Brasil Ortopedia 2010; 45(1): 17-22.

[11] Mixter W, Barr J. Rupture of intervertebral disc with involvement of the spinal. N Engl J Med 1934; 211: 210-14.

[12] Krismer M, van Tulder M. Strategies for prevention and management of musculoskeletal conditions. Low back pain (nonspecific). Best Pract Res Clin Rheumatol 2007; 21(1): 77-91.

[13] Mann L, Kleinpaul JF, Pereira Moro AR, Mota CB, Carpes FP. Effect of low back pain on postural stability in younger women: influence of visual deprivation. J Bodyw Mov Ther 2010; 14(4): 361-6.

[14] Ruhe A, Fejer R, Walker B. Is there a relationship between pain intensity and postural sway in patients with non-specific low back pain? BMC Musculoskelet Disord 2011; 12: 162.

[15] Alexander NB, Ulbrich J, Raheja A, Channer D. Rising from the floor in older adults. J Am Geriatr Soc 1997; 45(5): 564-9.

[16] Daley MJ, Spinks WL. Exercise, mobility and aging. Sports Med 2000; 29(1): 1-12.

[17] Teimoori A, Kordi M, Choobine S, Heidari B. The effects of aging on muscle strength and functional ability of healthy Iranian Males. World J Sport Sci 2009; 2(4): 261-5.

[18] Morrison S, Colberg SR, Mariano M, Parson HK, Vinik AI. Balance training reduces falls risk in older individuals with type 2 diabetes. Diabetes Care 2010; 33(4): 748-50.

[19] Onishi J, Umegaki H, Suzuki Y, Uemura K, Kuzuya M, Iguchi A. The relationship between functional disability and depressive mood in Japanese older adult inpatients. J Geriatr Psychiatry Neurol 2004; 17(2): 93-8.

[20] Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol 1994; 49(2): M85-94.

[21] Araújo CGS. Teste de sentar-levantar: apresentação de um procedimento para avaliação em Medicina do Exercício e do Esporte. Rev Bras Med Esporte 1999; 5(5): 179-82.

[22] Akuthota V, Nadler SF. Core strengthening. Arch Phys Med Rehabil 2004; 85(3 Suppl 1): S86-92.

[23] Mou W, McNamara TP, Valiquette CM, Rump B. Allocentric and egocentric updating of spatial memories. J Exp Psychol Learn Mem Cogn 2004; 30(1): 142-57.

[24] Baumeister J, Reinecke K, Cordes M, Lerch C, Weiss M. Brain activity in goal-directed movements in a real compared to a virtual environment using the Nintendo Wii. Neurosci Lett 2010; 481(1): 47-50.

[25] Gil-Gomez JA, Llorens R, Alcaniz M, Colomer C. Effectiveness of a Wii balance board-based system (eBaViR) for balance rehabilitation: a pilot randomized clinical trial in patients with acquired brain injury. J Neuroeng Rehabil 2011; 8: 30.

[26] Young W, Ferguson S, Brault S, Craig C. Assessing and training standing balance in older adults: a novel approach using the 'Nintendo Wii' Balance Board. Gait Posture 2011; 33(2): 303-5.

[27] Lin CT, Chen SA, Chiu TT, Lin HZ, Ko LW. Spatial and temporal EEG dynamics of dual-task driving performance. J Neuroeng Rehabil 2011; 8: 11.

[28] Eley KA. A Wii fracture. N Engl J Med 2010; 362: 473-4.

[29] Sparks D, Chase D, Coughlin L. Wii have a problem: a review of self-reported Wii related injuries. Inform Prim Care 2009; 17(1): 55-7.

[30] Kim JH, Jang SH, Kim CS, Jung JH, You JH. Use of virtual reality to enhance balance and ambulation in chronic stroke: a doubleblind, randomized controlled study. Am J Phys Med Rehabil 2009; 88(9): 693-701.

[31] Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. Med Sci Sports Exerc 2009; 41(7): 1510-30.

[32] Ransford A, Cairns D, Mooney V. The pain drawing as an aid to the psychologic evaluation of patients with low-back pain. Spine 1976; 1(2): 127-34.

[33] Clark RA, Bryant AL, Pua Y, McCrory P, Bennell K, Hunt M. Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. Gait Posture 2010; 31(3): 307-10.

[34] Viana MF, de Almeida PL, Santos RC. Adaptação portuguesa da versão reduzida do Perfil de Estados de Humor: POMS. Anál Psicol 2001; 1(19): 77-92.

[35] Vincent WJ. Statistics in Kinesiology. 3rd ed.: Hum Kinetics 2005; pp. 230-4.

[36] Hopkins WG. Institute of Sport & Recreation Research. Auckland: Sport Science; 2009 Available from: [http: //sportsci.org/will/] cited 24th September 2011.

[37] Gutierrez-Martinez O, Gutierrez-Maldonado J, Loreto-Quijada D. Control over the virtual environment influences the presence and efficacy of a virtual reality intervention on pain. Stud Health Technol Inform 2011; 167: 111-5.

[38] Dahlquist LM, Herbert LJ, Weiss KE, Jimeno M. Virtual-reality distraction and cold-pressor pain tolerance: does avatar point of view matter? Cyberpsychol Behav Soc Netw 2010; 13(5): 587-91.

[39] Law EF, Dahlquist LM, Sil S, et al. Videogame distraction using virtual reality technology for children experiencing cold pressor pain: the role of cognitive processing. J Pediatr Psychol 2011; 36(1): 84-94.

[40] Li A, Montano Z, Chen VJ, Gold JI. Virtual reality and pain management: current trends and future directions. Pain Manag 2011; 1(2): 147-57.

[41] Patterson DR, Jensen MP, Wiechman SA, Sharar SR. Virtual reality hypnosis for pain associated with recovery from physical trauma. Int J Clin Exp Hypn 2010; 58(3): 288-300.

[42] Faries MD, Greenwood M. Core training: Stabilizing the confusion. Strength Condition J 2007; 29(2): 10-25.

[43] Monteiro Junior RS, da Silva EB. Virtual rehabilitation effectiveness in the body balance and motor skills of individuals with neuromotor deficit: a systematic review. Rev Bras Ativid Física Saúde 2013; 17(3): 224-30.

[44] Brumagne S, Janssens L, Janssens E, Goddyn L. Altered postural control in anticipation of postural instability in persons with recurrent low back pain. Gait Posture 2008; 28(4): 657-62.

[45] Rauschecker JP, Korte M. Auditory compensation for early blindness in cat cerebral cortex. J Neurosci 1993; 13(10): 4538-48.

[46] Liepert J, Miltner WH, Bauder H, et al. Motor cortex plasticity during constraint-induced movement therapy in stroke patients. Neurosci Lett 1998; 250(1): 5-8.

[47] Rey B, Alcaniz M, Naranjo V, Parkhutik V, Tembl J. Analysis of visual perception aspects of the virtual reality experience with transcranial Doppler monitoring. Stud Health Technol Inform 2010; 154: 105-9.

[48] Riecke BE, Cunningham DW, Bulthoff HH. Spatial updating in virtual reality: the sufficiency of visual information. Psychol Res 2007; 71(3): 298-313.

[49] Akiduki H, Nishiike S, Watanabe H, Matsuoka K, Kubo T, Takeda N. Visual-vestibular conflict induced by virtual reality in humans. Neurosci Lett 2003; 340(3): 197-200.

[50] Jorgensen MG, Laessoe U, Hendriksen C, Nielsen OB, Aagaard P. Efficacy of Nintendo Wii training on mechanical leg muscle function and postural balance in community-dwelling older adults: a randomized controlled trial. J Gerontol A Biol Sci Med Sci 2013; 68(7): 845-52.

[51] Merians AS, Poizner H, Boian R, Burdea G, Adamovich S. Sensorimotor training in a virtual reality environment: does it improve functional recovery poststroke? Neurorehabil Neural Repair 2006; 20(2): 252-67.

[52] Mirelman A, Patritti BL, Bonato P, Deutsch JE. Effects of virtual reality training on gait biomechanics of individuals post-stroke. Gait Posture 2010; 31(4): 433-7.

[53] Piron L, Turolla A, Agostini M, et al. Exercises for paretic upper limb after stroke: a combined virtual-reality and telemedicine approach. J Rehabil Med 2009; 41(12): 1016-102.

[54] Saposnik G, Teasell R, Mamdani M, et al. Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation: a pilot randomized clinical trial and proof of principle. Stroke 2010; 41(7): 1477-84.

[55] You SH, Jang SH, Kim YH, et al. Virtual reality-induced cortical reorganization and associated locomotor recovery in chronic stroke: an experimenter-blind randomized study. Stroke 2005; 36(6): 1166-71.

[56] Carvalho T, Nóbrega ACL, Lazzoli JK, et al. Position Stand of the Brazilian Society of Sports Medicine: Physical Activity and Health. Rev Bras Med Esporte 1996; 2(4): 79-81.