TRAINING WITH WII BALANCE BOARD FOR DYNAMIC BALANCE IN OLDER ADULTS

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ABSTRACT

Background and Purpose: Age-related muscle strength deterioration, as well as decreased ability to react appropriately and regain balance after unexpected sudden disturbances and deficit they have in the use of responsible mechanisms to control the dynamic stability in response to a disturbance are important intrinsic risk factors for the fall. The main objective of this study is to verify the impact on the dynamic balance, through the Limits of Stability test (LOS), of a physical exercise program in older adults using the Nintendo Wii® console.

Methods: The sample consisted of a total of 12 patients. Pre and post-treatment measurements and assessments were carried out at the Laboratory of Motion Analysis, Biomechanics, Ergonomics and Motor Control (LAMBECOM) in the Faculty of Health Sciences of the Rey Juan Carlos University.

Results and Conclusions: The results of this study show improvements in the scores of all the variables analyzed by LOS: RT, MVL, EPE, MXE and DCL. The results obtained seem to determine that the protocol used through training with the Nintendo Wii® and its Wii Fit ™ video game produced clinical improvements in postural control and dynamic balance and a positive impact on quality of life.

KEY WORDS: aging; balance; elderly; postural stability; virtual reality; Nintendo Wii®.

INTRODUCTION

According to the World Health Organization (WHO), the number of people over 60 is increasing exponentially due to the increase in life expectancy and the decline in the fertility rate [1, 2] .

It is important to know the relationship between posture and balance with age. Perceptual inhibition and cognitive involution and brain structures, characteristic of the natural devaluation of the human being, result in difficulty maintaining balance in older adults [3,4]. Age-related muscle strength deterioration, as well as decreased ability of adults to react appropriately and regain balance after unexpected sudden disturbances are important intrinsic risk factors for the fall [5]. Another factor that is behind the deterioration of the balance in older adults is the deficit they have in the use of responsible mechanisms to control the dynamic stability in response to a disturbance [6]. This implies an increased risk of falls and therefore higher costs for the health system [7]. Thus, around 30% of the elderly with 65 years or more experience a fall at least once a year, and 15% fall two or more times per year [8].

In recent years, interventions have been developed to improve balance and reduce the risk of falls in older adults. It has been observed that the key components that the intervention programs must include are balance exercises, muscular strength, flexibility and resistance. However, one drawback of conventional exercise programs is that they suffer from low adherence, especially if prevention is the goal since those programs generally begin after one or more falls with serious consequences [9]. Early detection of abnormalities in balance dynamic followed by adequate rehabilitation can help prevent falls, substantially improving the quality of life of the elderly [10].

Low-cost virtual reality (VR) systems have been used for balance training in older people; these systems simulate a real environment allowing the subject to interact with the elements of the environment following the theory of task-oriented learning [11]. One of these Low cost RV devices is the Nintendo Wii® console which consists of exercise-based game software. This system combines fun and physical exercise for all ages, including work on aspects such as joint flexibility, muscular strength and postural ergonomics [12].

It has been shown that the use of the Nintendo Wii® system as training to improve the static balance in older people is effective [13-16], but in our knowledge there are no studies that evaluate the dynamic balance after training with the Nintendo Wii® system. For this reason, the main objective of this study is to verify the impact on the dynamic balance, through the Limits of Stability test (LOS), of a physical exercise program in older adults, based on proprioception activities, re-education of the Balance and physical exercise using the Nintendo Wii® console. Likewise, it is intended to evaluate the impact on the quality of life; an improvement of the dynamic balance would cause a better functioning and participation of the individuals.

METHODS

Design

It is a prospective longitudinal study with pre and post-intervention assessment. The procedure for the selection of the subjects was a consecutive nonprobabilistic sampling. All assessments were made by a blind evaluator, other than the physiotherapist who performed the treatment sessions. This study was approved by the ethics committee by the Rey Juan Carlos University.

Subjects

The voluntary participation of older adults who met the following inclusion criteria was requested: ages between 74 and 85 years, ability to maintain stability in standing without support products, independent walking ability and ability to understand instructions. Excluded from the study were those subjects who presented uncontrolled orthostatic hypotension, significant visual deficit, joint instability, neurological pathologies (Stroke, Parkinson's, Alzheimer ...), positive Romberg, severe osteoarthritis and severe cognitive impairment. All patients were informed verbally and in writing about the characteristics of the study. After agreeing, they signed the informed consent.

Procedure

Pre and post-treatment measurements and assessments were carried out at the Laboratory of Motion Analysis, Biomechanics, Ergonomics and Motor Control (LAMBECOM) in the Faculty of Health Sciences of the Rey Juan Carlos University.

After the initial assessment, a home physiotherapy treatment was carried out through the Nintendo Wii® console and its Wii Balance Board accessory. The treatment period was 4 weeks with 2 sessions during each week. The duration of each session was 45 minutes.

The exercises performed were those included in the Wii Fit Plus ™ Software. First, the "Physical Test" was performed to make the subject aware of good postural control through the correct situation of the center of gravity (COG). Afterwards, the different warm-up exercises (yoga and strengthening exercises) were carried out and subsequently various exercises of re-education of posture and balance were carried out.

During the sessions a physiotherapist was present who at all times controlled the treatment. The safety above the WBB, the tolerance to the efforts made and the limits of stability during the treatment were supervised, given their advanced age.

Outcome measures

The computerized dynamic posturography (CDP) is an objective method that allows to quantify the postural control of the subject due to the displacements of the center of pressures, being considered as the gold test ("Gold Standard"). In this study, the Smart Equitest System® version 8.2 (Neurocom International Inc, Clackamas, Oregon, USA) has been used as CDP. The posturographic analysis was performed using the LOS test, which quantifies the ability of the subject to move its center of gravity to 8 different positions in space without taking off the feet of the platform and maintain the balance in the maximum distance achieved. The parameters to be evaluated are: reaction time (RT), which are the seconds elapsed since the patient receives the signal until the movement begins; Movement speed (MS) measured in degrees per second; endponit excursion (EPE) translated into the distance traveled by the center of gravity in the first attempt to reach the objective; Maximum excursion (MXE) is the maximum distance traveled by the center of gravity during the test; and directional control (DCL) which is the ability to control the displacement of the center of gravity [17-19].

The SF-36 health questionnaire is one of the instruments of Quality of Life Related to Health. It has 36 items that assess positive and negative health states, classified into 9 scales: physical function (PF), limitations due to physical health problems (role-physical, RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), limitations due to emotional health problems (role-emotional, RE) and mental health (MH). In order to analyze the results, a raw score is calculated for each scale and then transformed into values from 0 to 100 (where high scores reflect a better state of health) [20-23].

Statistical Analysis

The statistical analysis was performed using the SPSS statistical software system (SPSS Inc., Chicago, IL; version 22.0). The Shapiro Wilk's test and the Kolmogorov-Smirnov test were used to screen all data for normality of distribution. Additionally, the Wilcoxon test for related samples was used to compare variables. The statistical analysis was performed with a 95% confidence level, and significant values were considered as $p < 0.05$.

RESULTS

The sample consisted of a total of 14 patients of the 16 patients recruited initially. Of the two patients who did not complete the study, one suffered a stroke before performing the post-treatment assessment and the other left due to a change of province. The mean age ± standard deviation of the sample was 80.75 ± 3.66.

The different variables analyzed for the LOS show statistically significant differences according to the positions between the pre- and post-treatment evaluations. It is worth mentioning that position 5 (posterior direction) is the only one where all the variables studied obtain statistically significant results (Table 1).

The statistical data show faster average reaction times in all journeys. Statistically significant differences were found in the TR for the posterior displacement p = 0.012 [DM = -1.56; 95% CI = -2.81 / -0.31], posterior oblique shift to the left p = 0.050 [DM = -1.37; 95% CI = -2.39 / -0.34] and lateral shift to the left p = 0.021 [DM = -1.16; 95% CI = -2.41 / 0.09]. Faster movements were observed in all displacements, measured through degrees per second. The MS that obtained statistically significant differences were in: anterior displacement p = 0.021 [DM = 0.69; 95% CI = 0.27 / 1.11], anterior oblique shift to the right p = 0.012 [DM = 1.15; 95% CI = 0.59 / 1.71], posterior displacement p = 0.028 [DM = 0.76; 95% CI = 0.19 / 1.34], posterior oblique shift to the left p = 0.012 [DM = 1.24; 95% CI = 0.59 / 1.89] and anterior oblique shift to the left p = 0.021. [DM = 0.90; 95% CI = 0.28 / 1.52]. The EPE was greater in all the displacements. The results where statistically significant differences were found were for: posterior oblique displacement to the right p = 0.012 [DM = 7.50; 95% CI = 1.90 / 13.10], posterior displacement p = 0.043 [DM = 18.88; 95% CI = 1.65 / 36.10], posterior oblique shift to the left p = 0.012 [DM = 17.75; 95% CI = 8.62 / 26.88] and lateral shift to the left p = 0.050 [DM = 9.75; 95% CI = -0.82 / 20.32]. The maximum distance traveled by the center of gravity during the test was greater in all displacements. The statistically significant results of the MXE were obtained in the displacements: anterior oblique to the right p = 0.012 [DM =

14.25; IC95% = 2.55 / 25.95], lateral to the right p = 0.028 [DM = 14.25; 95% CI = -0.08 / 24.58], posterior oblique to the right p = 0.042 [DM = 6.63; 95% CI = 0.12 / 13.13], later p = 0.018 [DM = 15.38; 95% CI = 1.23 / 29.52], posterior oblique to the left p = 0.036 [DM = 16.75; IC95% = 3.90 / 29.60], lateral to the left p = 0.012. [DM = 16.50; 95% CI = 7.62 / 25.38]. The ability of the patient to control the displacement of the center of gravity has shown more varied results. Improvements have been found in all DCL values for all displacements except for the oblique displacements to the left and right. The posterior displacement is the only one that has shown statistically significant differences p = 0.042 [DM = 37.00; 95% CI = 4.96 / 69.04]. The results obtained from the responses of the patients to the Health Questionnaire SF-36 (pre- and post-treatment) showed statistically significant differences in VT p = 0.046 [DM = 2.50; 95% CI = 0.27 / 4.73] and RE p = 0.038 [DM = 5.91 / 52.44]. Improvements were obtained in all scale scores except for the GH scale that remained the same (Table 2).

DISCUSSION

The results of our study show that the physiotherapy intervention based on Nintendo Wii® is capable of improving dynamic balance, postural control, and of having a positive impact on the quality of life of older adults. Molina et al. [24] through their systematic review reported on the lack of consensus on the duration of treatment and benefits in physical function; however, all agree on the positive motivational aspect of its use.

Dynamic balance is essential for motor control and depends on the center of gravity (COG), weight shifts and the activation of the musculature [25]. The importance of the LOS test lies in that to assess the dynamic posture and functional stability to detect the risk of falls in patients. The LOS postural control refers to the maximum voluntary distance or angle at which an individual can regulate their COG in a given direction without losing their balance [26]. Previous studies showed that older adults have altered stability limits, as well as reaction, worse directional control and greater difficulty in postural control than younger adults [27-29]. Furthermore, it has been shown that these values directly influence an increase in the risk of falls [30].

Hamed et al. [31] stated that a training program based on balance disturbances in older adults focused on exercising mechanisms of dynamic stability has the potential to improve muscle strength as well as the dynamic balance assessed by a test of anterior LOS with a force platform. It was achieved, as a result of the improvements obtained, to reduce the risk of falls in older adults. Young et al. [32] proposed that the use of virtual reality as training for the elderly is safe and economical, and that may encourage user interest. Interventions that use virtual reality can improve the balance and progress of patients and develop their fine motor function, gross motor function and coordination. In addition, virtual reality training is a safe and useful tool to improve sensorimotor functions. It is an effective alternative as physical therapy in the home.

It has been shown that interventions of physical exercise in older adults, such as strength training and retraining of the balance, reduce the rates of falls and the risk of falling. In this way, they reduce the injuries derived from falls and the fear of falling that elderly adults present [33,34]. Balance training is considered an important aspect of a fall prevention program in older adults [35] [35].

The results of this study show improvements in the scores of all the variables analyzed by LOS: RT, MVL, EPE, MXE and DCL. It is important to emphasize that the differences observed were greater than the minimum detectable changes obtained in EPE and MXE in healthy subjects (6.2 and 5.9 points, respectively) [36]. Therefore, the results obtained in the present study were not the result of patient learning, were improvements produced by the effectiveness of the therapy carried out. De Vries et al. [37] affirmed that the use of low cost VR devices produces improvements in the retraining of the dynamic balance of older adults. These results are shown in agreement with the results obtained, although these did not use a PDC to assess LOS, they used a functional test of stability limits. It is important to note that their findings show no improvement in subsequent displacements due to the lack of incentives to move in a later direction in training, as opposed to our results. However, Hakim et al. [38] described the effects of Nintendo Wii® system training in an older adult with peripheral neuropathy. They used the PDC to perform the LOS test and observed that they improved the maximum excursion capacities and the posterior displacements. What coincides with the results obtained in the present study. On the other hand, Hakim et al. [39] resumed the effects of one hour of training using the PDC in a geriatric population with stroke. The results showed improvements in the LOS scores and, therefore, in the risk reduction of falls, which agrees with the results obtained in the present study, although they did not use low reality systems and the sample was of a single older adult with stroke.

Regarding the SF-36 Questionnaire, we have obtained improvements in all the scores (except in the GH scale) although none of them is statistically significant. Franco et al. [40] also did not obtain statistically significant differences in quality of life but concluded that it is a fun form of treatment for older adults and that it can be used as a rehabilitation tool.

This study has methodological limitations such as small sample size, the absence of control group and lack of follow-up measures. Further studies should be conducted by increasing the simple in order to generalize the results. Second it would be necessary to include control group to compare patients who do not perform any exercise or conventional exercise programs and follow-up measures to know if the results are maintained over time.

CONCLUSIONS

The current work has allowed to verify the benefits resulting from the treatment with the Nintendo Wii®. Despite the small sample size, the results obtained seem to determine that the protocol used through training with the WBB and its Wii Fit ™ video game produced clinical improvements in postural control and dynamic balance and a positive impact on quality of life.

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Table 1: *Results from the LOS*

VARIABLE		MEAN± SD		DM	Z	p VALUE	CI 95 %
		PRE	POST				
RT	1	1,81 ± 1,30	1,52 ± 1,01	-0,30	-0,98	0,327	From -1,60 to 1,00
	2	1,30 ± 1,27	0,90 ± 0,60	-0,40	-0,84	0,401	From -1,32 to 0,52
	3	1,90 ± 1,44	0,90 ± 0,79	-1,00	-1,68	0,093	From -2,31 to 0,30
	4	1,39 ± 1,16	1,12 ± 0,94	-0,28	-1,40	0,161	From -1,49 to 0,94
	5	2,79 ± 1,07	1,23 ± 0,94	-1,56	-2,52	0,012*	From -2,81 to -0,31
	6	2,25 ± 1,10	0,88 ± 0,76	-1,37	-1,96	0,050*	From -2,39 to -0,34
	7	1,67 ± 1,45	0,51 ± 0,51	-1,16	-2,31	0,021*	From -2,41 to 0,09
	8	1,11 ± 1,03	0,75 ± 0,58	-0,36	-1,12	0,262	From -1,13 to 0,42
MVL	1	1,03 ± 0,59	1,71 ± 0,58	0,69	-2,31	0,021*	From 0,27 to 1,11
	2	0,91 ± 0,58	2,06 ± 0,82	1,15	-2,52	0,012*	From 0,59 to 1,71
	3	0,96 ± 0,54	2,00 ± 1,31	1,04	-1,82	0,069	From -0,09 to 2,16
	4	1,45 ± 1,24	1,79 ± 1,15	0,34	-0,91	0,362	From -0,39 to 1,06
	5	0,21 ± 0,60	0,98 ± 0,78	0,76	-2,20	0,028*	From 0,19 to 1,34
	6	0,59 ± 0,72	1,83 ± 0,61	1,24	-2,52	0,012*	From 0,59 to 1,89
	7	1,79 ± 1,24	2,04 ± 0,94	0,25	-0,56	0,574	From -0,65 to 1,15
	8	1,19 ± 0,84	2,09 ± 0,93	0,90	-2,31	0,021*	From 0,28 to 1,52
EPE	1	35,25 ± 19,07	40,87 ± 16,06	5,62	-0,56	0,575	From -9,48 to 20,73
	2	31,75 ± 25,36	44,75 ± 19,96	13,00	-1,68	0,092	From -4,51 to 30,51
	3	28,00 ± 17,60	34,63 ± 10,72	6,63	-1,12	0,262	From -7,67 to 20,92
	4	20,75 ± 14,95	28,25 ± 12,92	7,50	-2,53	0,012*	From 1,90 to 13,10
	5	3,88 ± 10,96	22,75 ± 20,32	18,88	-2,02	0,043*	From 1,65 to 36,10
	6	14,88 ± 16,18	32,63 ± 13,50	17,75	-2,52	0,012*	From 8,62 to 26,88
	7	31,62 ± 13,79	41,38 ± 13,45	9,75	-1,96	0,050*	From -0,82 to 20,32

	8	41,88 ± 31,33	45,00 ± 26,16	3,13	-0,70	0,483	From -10,87 to 17,12
MXE	1	45,50 ± 27,10	60,50 ± 22,15	15,00	-1,69	0,091	From -4,89 to 34,89
	2	46,25 ± 32,37	60,50 ± 27,45	14,25	-2,53	0,012*	From 2,55 to 25,95
	3	34,88 ± 17,15	47,13 ± 19,20	12,25	-2,20	0,028*	From -0,08 to 24,58
	4	26,00 ± 14,72	32,63 ± 15,58	6,63	-2,03	0,042*	From 0,12 to 13,13
	5	13,50 ± 11,24	28,88 ± 18,45	15,38	-2,37	0,018*	From 1,23 to 29,52
	6	27,13 ± 21,01	43,88 ± 18,98	16,75	-2,10	0,036*	From 3,90 to 29,60
	7	45,00 ± 19,74	61,50 ± 20,31	16,50	-2,52	0,012*	From 7,62 to 25,38
	8	57,38 ± 32,64	66,13 ± 26,46	8,75	-1,54	0,123	From -5,94 to 23,44
DCL	1	66,63 ± 25,37	71,00 ± 24,73	4,38	-0,14	0,889	From -11,65 to 20,40
	2	51,00 ± 41,33	66,00 ± 25,67	15,00	-1,36	0,173	From -3,81 to 33,81
	3	57,88 ± 25,49	61,13 ± 19,14	3,25	-0,35	0,726	From -12,09 to 18,59
	4	17,50 ± 23,99	15,63 ± 24,37	-1,87	-0,41	0,686	From -32,10 to 28,35
	5	5,50 ± 15,56	42,50 ± 36,34	37,00	-2,03	0,042*	From 4,96 to 69,04
	6	28,75 ± 34,00	21,63 ± 34,07	-7,13	-0,73	0,465	From -26,26 to 12,01
	7	66,25 ± 28,76	66,75 ± 23,34	0,50	-0,28	0,779	From -13,50 to 14,50
	8	55,75 ± 37,16	68,25 ± 22,14	12,50	-1,54	0,123	From -6,31 to 31,31

RT: reaction time; MS: movement speed; EPE: endponit excursion; MXE: Maximum excursion; DCL: directional control.

1: forward direction; 2: right oblique and forward direction 3: right direction; 4: right oblique and backward direction; 5: backward direction; 6: left oblique and backward direction; 7: left direction; 8: left oblique and forward direction.

Data are expressed as mean ±SD. Comparisions between groups are expressed in difference of means (DM) and 95% confidence interval (CI).

*p value < 0.05 using Wilkoxon test for related samples

Table 2: *Results from the SF-36 health questionnaire*

VARIABLE	MEAN± SD		DM	Z	p VALUE	CI 95 %
	PRE	Post				
PF	52,50 ± 38,36	54,38 ± 39,68	1,88	-1,34	0,18	From -1,24 to 4,99
RP	68,75 ± 45,81	75,00 ± 46,29	6,25	-1,00	0,32	From -8,53 to 21,03
BP	54,13 ± 31,02	70,50 ± 28,54	16,38	-1,83	0,068	From -7,96 to 40,71
GH	63,50 ± 26,48	63,50 ± 26,80	0,00	0,00	1,00	From -2,23 to 2,23
VT	53,13 ± 32,94	55,63 ± 31,21	2,50	-2,00	0,046*	From 0,27 to 4,73
SF	68,75 ± 17,68	85,94 ± 22,60	17,19	-1,55	0,121	From -4,40 to 38,78
RE	70,82 ± 27,83	100,00 ± 0,00	29,18	-2,07	0,038*	From 5,91 to 52,44
MH	70,00 ± 30,39	77,00 ± 22,40	7,00	-1,80	0,072	From -1,71 to 15,71

PF: physical function; RP: limitations due to physical health problems (role-physical); BP: bodily pain; GH: general health; VT: vitality; SF: social functioning; RE: limitations due to emotional health problems (role-emotional); MH: mental health.

Data expressed as mean ± (SD). DM is difference of means. CI 95% is confidence interval.

**p value < 0.05 using Wilkoxon test for related samples*