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Original Article

Effects of a Nintendo Wii exercise program versus Tai Chi Chuan on standing balance in older adults: a preliminary study

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Abstract. [Purpose] This study compared the effect of the Nintendo Wii balance board (NWBB) and Tai Chi Chuan (TCC) on the standing balance (SB) of older adults. [Participants and Methods] Twelve older adults (NWBB=7 and TCC=5) completed the intervention and two testing sessions (pre-post). SB was assessed using posturographic measures with the center of pressure (CoP) in five modes: quiet eyes open (QSB-EO) and eyes closed (QSB-EC), on sponge (SBS-EO and SBS-EC), and with optokinetic field (SB-OF). [Results] Both interventions significantly decrease the area of CoP sway (CoP_{Sway}) in QSB-EO and SB-OF. The NWBB-group decreased CoP_{Sway} in SBS-EC and CoP velocity (V_{mean}) in QSB-EO, QSB-EC, and SBS-EC. The TCC-group decreased the V_{mean} in SBS-EO and conversely the V_{mean} in QSB-EC increased. [Conclusion] Sponge and optokinetic field were the most unstable assessments. These findings reveal the potential benefits for SB of both interventions, however the NWBB improved more variables in the postural control of older adults.
Key words: Nintendo Wii, Tai Chi Chuan, Older adult

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INTRODUCTION

The risk of falling in elderly people is multifactorial, but postural instability or the inability to maintain standing balance is a major risk factor for falls and their concomitant consequences in the elderly[1, 2)]. Fall injuries related to the loss of balance in the elderly are a public health problem because they are strongly associated with hip fractures, which have a high mortality and morbidity in the world[3)]. Many strategies are recommended for reducing the incidence of falls in older adults, including regular physical exercises (focused on balance and strength training), home hazard reduction, and adjustment of medication, among others[4, 5)].

Tai Chi Chuan, better known as Tai Chi (TCC), may be particularly beneficial to older adults with mild cognitive impairment (MCI) because it incorporates physical and mental activity. TCC involves whole-body coordination of continuous,

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rhythmic movements with dynamic weight shifting and single-limb support. Moreover, TCC requires several cognitive activities involving movement recall, switching, and spatial orientation that require attention and executive control[6].

Long-term regular TCC practice has been shown to improve the neuromuscular reaction of the erector spinae and tibialis anterior to lateral perturbation and will help timely posture correction when lateral postural distributions occur[7]. Moreover, TCC has been proved to improve balance using several tests, such as the Get Up and Go, Single-leg Stand, and Berg tests[8]. However, the results on research on TCC are not conclusive and the mechanisms involved in TCC practice need to be elucidated[9].

On the other hand, virtual reality (VR) interfaces device such as Nintendo Wii balance board (NWBB), which provide abundant multisensory stimuli (visual, vestibular, proprioceptive, and auditory), have been used for to improve the standing balance (SB) in older adults[10]. However, there is no comparative evidence of the effects of an NWBB exercise program versus TCC in the SB in older adults.

The aim of this preliminary study was to compare the effects of the NWBB and TCC on the SB of older adults.

PARTICIPANTS AND METHODS

Twelve older adults participated in a study design pretest/posttest. Seven were allocated to the NWBB group and five to the TCC group. The study sample was obtained from two centers for older adults in the city of Talca, Chile. Older adults between 65 and 75 years, a Mini Mental State Examination (MMSE) score of over 17 points and no falls in the last 12 months were included, and with vestibular impairment were excluded. All participants provided a voluntary signed informed consent form. This research was approved by the ethical committee of the Universidad de Talca, Chile (Ref. No.14) in accordance with the Declaration of Helsinki.

Measures were taken in the Biomechanics Laboratory of the Universidad de Talca at baseline and immediately after the 6-week NWBB and TCC protocols. Participants stood on a force plate (artOficio) were assessed under five conditions for 30 seconds each: quiet standing balance with eyes open and closed (QSB-EO and QSB-EC), standing balance on sponge with eyes open and closed (SBS-EO and SBS-EC), and the visual influence was considered particularly when the visual field was in motion; for this, standing observing optokinetic fields (SB-OF) was assessed. Data were collected and recorded at 100 Hz. A procedure written in Matlab R2012 (Mathworks Inc., Natick, MA, USA) was used for low-pass filtering data (second-order Butterworth, 40 Hz cutoff frequency) and to calculate center-of-pressure (CoP) variables such as area of CoP sway (CoP_{Sway}) and mean velocity of CoP (mV).

The interventions were established in the respective centers for older adults. Each intervention comprised a total of 18 sessions (NWBB was 25 minutes/session and TCC was 60 minutes/session) that were delivered over a period of six-weeks at a frequency of three times per week, based on the minimum time to generate changes in postural control reported in the NWBB exercise program[10].

NWBB games from Wii Fit Plus were projected onto a 2 × 2 m screen placed 1.8 m in front of the participants using a high-definition beam projector. The protocol includes three sets of exercises, always under the supervision of a physical therapist. The types of Wii Fit exercises were based on a previous study, where the games that trained the balance in the three planes of movement were chosen[10]. The exercises were: Snowboard, Penguin Slide, and Super Hula Hoop for the first two series of exercises and the Yoga game for the third series. In the first series, participants were standing with their arms and hands at their sides, in a relaxed manner. In the second series, each game was repeated in a standing position and with their hands on their waist. In the third series, the participants maintain their posture as relaxed as possible with eyes open, and later with eyes closed.

TCC group involved stretching the neck, shoulders, hips, knees, and ankles. A series of exercises was performed to increase the stability of the trunk and lower limbs muscles. Balance training included rising from a sitting position to a standing position, standing on one leg, tandem walking, walking backward and sideways, and turning 360°.

Means and standard deviations for the demographic and anthropometric characteristics were obtained. The differences pre/post training for total of the participants was obtained by Wilcoxon signed-rank test. IBM-SPSS 20.00 was used (SPSS Inc., IL, USA), the level of significance set at $p<0.05$.

RESULTS

Twelve out of fifteen participants completed all of the sessions performed in six weeks (NWBB: 7.5 h and TCC: 18 h). Characteristic demographics for each group are shown in Table 1.

Table 2 shows the pre- and post-intervention values for CoP_{sway} and mV, including the pre/post comparisons for each intervention.

DISCUSSION

We note that despite a statistically significant effect of both interventions on several SB variables, especially for the NWBB, there was no clear superiority of one over the other.

Table 1. Characteristic demographics of study groups

Characteristics	NWBB	TCC	p-value
Age, years (mean ± SD)	69.14 ± 5.8	69 ± 3.67	0.9
Gender			
Female, n	5	3	
Male, n	2	2	
Weight, kg (mean ± SD)	73.0 ± 12.5	68.1 ± 10.7	0.5
Height, m (mean ± SD)	1.53 ± 0.07	1.56 ± 0.08	0.7
BMI, kg/m^2 (mean ± SD)	31.18 ± 2.5	28.02 ± 1.67	0.2

BMI: Body mass index; SD: standard deviation.

Table 2. Comparisons of pre-intervention and post-intervention for each study group

Measures	Group	Pre-intervention Median (IQR)	Post-intervention Median (IQR)	p-value
QSB-EO	NWBB	10.46 (6.37–17.62)	2.10 (1.69–3.53)	0.01
CoP_{Sway}	TCC	7.27 (4.47–14.03)	5.88 (3.78–10.38)	0.04
mV	NWBB	232.44 (226.75–257.45)	230.13 (228.26–233.86)	0.05
	TCC	232.45 (227.24–246.33)	231.97 (229.43–243.35)	0.45
QSB-EC	NWBB	9.41 (8.42–10.51)	7.16 (3.04–11.17)	0.06
CoP_{Sway}	TCC	6.35 (5.79–13.84)	10.92 (5.48–15.38)	0.25
mV	NWBB	247.70 (236.36–263.19)	232.34 (226.35–238.47)	0.02
	TCC	237.17 (233.46–248.13)	255.96 (237.68–271.18)	0.02
Sponge-EO	NWBB	15.83 (11.91–35.08)	12.94 (12.34–13.39)	0.21
CoP_{Sway}	TCC	18.34 (11.63–26.00)	17.75 (10.65–33.30)	0.25
mV	NWBB	282.52 (247.20–297.39)	275.57 (246.14–295.56)	0.43
	TCC	326.08 (290.02–337.24)	272.96 (267.27–285.75)	0.04
Sponge-EC	NWBB	17.87 (15.36–84.35)	17.29 (11.68–22.87)	0.05
CoP_{Sway}	TCC	17.87 (13.42–25.52)	26.15 (11.87–60.53)	0.11
mV	NWBB	361.28 (274.06–487.94)	282.77 (261.65–326.75)	0.03
	TCC	326.08 (290.02–337.24)	315.37 (277.03–350.75)	0.45
Optokinetic field	NWBB	6.039 (4.99–10.04)	5.74 (2.67–6.89)	0.05
CoP_{Sway}	TCC	17.87 (13.42–25.52)	26.15 (11.87–60.53)	0.11
mV	NWBB	232.01 (227.99–239.62)	237.29 (228.45–238.59)	0.31
	TCC	233.96 (229.82–238.47)	241.73 (228.15–256.03)	0.07

QSB-EO: Quiet standing balance in the eyes-open condition; QSB-EC: Quiet standing balance in the eyes-closed condition; Sponge-EO: sponge in eyes-open condition; Sponge-EC: sponge in eyes-closed condition; NWBB: Nintendo Wii balance board; TCC: Tai Chi Chuan; CoP_{Sway}: area of CoP sway in cm^2; mV: CoP mean velocity in cm/sec.

One of the main advantages of this study is the inclusion of CoP_{sway} and mV measurements in different situations. Thus, it is possible to obtain a better assessment of the effects on SB. However, there are no other studies including all these measurements for the NWBB and TCC, thereby making comparisons with the literature difficult.

With respect to TCC, our results are similar to those of Ghandali et al.[11] who evaluated this therapy in rigid and foam (sponge) surface situations. However, they evaluated stability and control in elder patients with knee osteoarthritis. As in our study, they found a reduction in CoP_{sway} and mV after 8 weeks of TCC therapy. In another trial, Sungkarat et al.[6] evaluated the effect of 12 weeks of TCC on cognitive and motor variables. They found a reduction in postural sway (using a sway meter at waist level) after the therapy.

With regard to the NWBB, the situation is very similar to that of TCC, but the NWBB improved more variables than TCC. This is in line with the literature, where a recent systematic review has shown the positive effect of exergame technology and interactive interventions, including the NWBB, on elderly fall prevention[12]. Indeed, the results of this study are similar to those previously published by our research team[10]. However, the NWBB has been extensively used in many populations with different pathologies, but no specific assessments of CoP_{sway} and mV as reported in this study have been found in the literature. Furthermore, recently two study protocols[13, 14] focused on assessing the effects of the Nintendo Wii have been

published, which highlights the importance and validity of this topic in geriatric research.

We found a negative effect in eyes-closed (without the vision) and optokinetic field (alteration of the visual field) conditions. This is important given that balance is more important in dynamic situations, and the prevalence of sight impairment in the elderly population. Kobayashi et al.[15] recently described the characteristics of accidental falls in a university hospital in Japan, and they found that most falls occur in a room at night, and mainly affect patients aged more than 70. They highlight the fact that vision restrictions (the lights are normally switched off in rooms at night) when patients try to go the bathroom are an important factor in the occurrence of falls. Thus, the assessment of postural balance must include eyes-closed or other creative restricted-vision conditions.

Barr et al.[16] evaluated the relationships between visual field dependence (VFD) and postural sway. They found that elderly people with VFD have a greater CoP_{sway} than patients without VFD. In our study, assessment in optokinetic field conditions has shown that there are fewer changes between pre- and post-intervention values, but no differentiation was made between VFD and non-VFD patients. Nevertheless, the minimal changes measured in the optokinetic field highlight the importance of deepening understanding of the relationship between VFD, SB and falls in the elderly.

The main limitation of this study is the reduced sample size, so future studies should increase the number of participants and parameters were not sufficient to compare in order to show the significance of the interventions. Another relevant consideration is the follow-up of patients after completing these kinds of intervention, taking into consideration the wane effect described.

Despite these limitations, NWBB and TCC improved the SB of older adults. However, the Nintendo Wii improved more balance parameters than Tai Chi. The results of sponge and optokinetic field settings were particularly erratic and neither of the interventions showed a clear superiority over the other.

Conflict of interest

None.

REFERENCES

1) Verma SK, Willetts JL, Corns HL, et al.: Falls and fall-related injuries among community-dwelling adults in the United States. PLoS One, 2016, 11: e0150939. [Medline] [CrossRef]
2) Hu J, Xia Q, Jiang Y, et al.: Risk factors of indoor fall injuries in community-dwelling older women: a prospective cohort study. Arch Gerontol Geriatr, 2015, 60: 259–264. [Medline] [CrossRef]
3) Nilsson M, Eriksson J, Larsson B, et al.: Fall risk assessment predicts fall-related injury, hip fracture, and head injury in older adults. J Am Geriatr Soc, 2016, 64: 2242–2250. [Medline] [CrossRef]
4) Pfortmueller CA, Lindner G, Exadaktylos AK: Reducing fall risk in the elderly: risk factors and fall prevention, a systematic review. Minerva Med, 2014, 105: 275–281. [Medline]
5) Karlsson MK, Vonschewelov T, Karlsson C, et al.: Prevention of falls in the elderly: a review. Scand J Public Health, 2013, 41: 442–454. [Medline] [CrossRef]
6) Sungkarat S, Boripuntakul S, Chattipakorn N, et al.: Effects of Tai Chi on cognition and fall risk in older adults with mild cognitive impairment: a randomized controlled trial. J Am Geriatr Soc, 2017, 65: 721–727. [Medline] [CrossRef]
7) Wang SJ, Xu DQ, Li JX: Effects of regular Tai Chi practice and jogging on neuromuscular reaction during lateral postural control in older people. Res Sports Med, 2017, 25: 111–117. [Medline] [CrossRef]
8) Huang Y, Liu X: Improvement of balance control ability and flexibility in the elderly Tai Chi Chuan (TCC) practitioners: a systematic review and meta-analysis. Arch Gerontol Geriatr, 2015, 60: 233–238. [Medline] [CrossRef]
9) Hackney ME, Wolf SL: Impact of Tai Chi Chu'an practice on balance and mobility in older adults: an integrative review of 20 years of research. J Geriatr Phys Ther, 2014, 37: 127–135. [Medline] [CrossRef]
10) Gatica Rojas V, Elgueta Cancino E, Vidal Silva C, et al.: Impacto del entrenamiento del balance a través de realidad virtual en una población de adultos mayores. Int J Morphol, 2010, 28: 303–308. [CrossRef]
11) Ghandali E, Moghadam ST, Hadian MR, et al.: The effect of Tai Chi exercises on postural stability and control in older patients with knee osteoarthritis. J Bodyw Mov Ther, 2017, 21: 594–598. [Medline] [CrossRef]
12) Choi SD, Guo L, Kang D, et al.: Exergame technology and interactive interventions for elderly fall prevention: a systematic literature review. Appl Ergon, 2017, 65: 570–581. [Medline] [CrossRef]
13) Gomes GC, Bacha JM, do Socorro Simões M, et al.: Feasibility, safety, acceptability, and functional outcomes of playing Nintendo Wii Fit Plus™ for frail elderly: study protocol for a feasibility trial. Pilot Feasibility Stud, 2017, 3: 41. [Medline] [CrossRef]
14) Montero-Alía P, Muñoz-Ortiz L, Jiménez-González M, et al.: Study protocol of a randomized clinical trial evaluating the effectiveness of a primary care intervention using the Nintendo™ Wii console to improve balance and decrease falls in the elderly. BMC Geriatr, 2016, 16: 8. [Medline] [CrossRef]
15) Kobayashi K, Imagama S, Inagaki Y, et al.: Incidence and characteristics of accidental falls in hospitalizations. Nagoya J Med Sci, 2017, 79: 291–298. [Medline]
16) Barr CJ, McLoughlin JV, van den Berg ME, et al.: Visual field dependence is associated with reduced postural sway, dizziness and falls in older people attending a falls clinic. J Nutr Health Aging, 2016, 20: 671–676. [Medline] [CrossRef]