ORIGINAL ARTICLE

Balance quantification with videogame: pilot study

Quantificação do equilíbrio pelo videogame: estudo piloto

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ABSTRACT

Seventh generation video games (VG) propose various balancing tests to asses the stability of the user. However, the parameters used to provide the score of these tests are not reported in the literature, nor is their relationship to clinical practice and user functionality. **Objective:** The objective of this study was to correlate the scores obtained by the balance platform of the Wii video game with kinetic variables provided by a force platform in simultaneous measurements. **Methods:** This pilot study included two subjects with stroke and two with traumatic brain injury. The kinetic variables analyzed were: area, movement speed, and root mean square of center of pressure (COP) position in the medial-lateral and anterior-posterior directions, and were processed in Matlab 7.0® and correlated with the score provided by the console (balancing tests: Single-leg test - SL - and Steadiness test - ST -) using the Pearson and Spearman correlation coefficients, both with $p < 0.05$. **Results:** A moderate correlation was found between the SL score and RMSy (r = 0.5839). When comparing the ST score to the variables: area (r = 0.8164), RMSx (r = -0.6418) and RMSy (r = -0.8094) the correlation was moderate to strong. **Conclusion:** No correlation was found between the console tests and the movement speed of the center of pressure measured on the force platform. It is concluded that the score of VG presented significant correlation with the kinetic variables, but the method is not practical for being employed in a clinical evaluation.

Keywords: Video Games, Postural Balance, Stroke, Rehabilitation

RESUMO

Os videogames (VG) de sétima geração propõe uma avaliação física que inclui diversos testes de equilíbrio. Porém não são reportados na literatura os parâmetros utilizados para fornecer a pontuação destes testes e se estes podem ser relacionados a prática clínica e funcionalidade do usuário. **Objetivo:** O objetivo do presente estudo foi de correlacionar as pontuações obtidas pelos testes da plataforma de equilíbrio do VG *Wii*® com as variáveis cinéticas fornecidas pela plataforma de força, a qual estava integrada a plataforma de equilíbrio do VG. **Método:** Participaram deste estudo piloto, dois indivíduos com diagnóstico de acidente vascular encefálico (AVE) e dois de traumatismo craniano (TCE). As variáveis cinéticas analisadas foram área, velocidade de deslocamento e valor quadrático médio da posição média (RMS) nos eixos médio-lateral (x) e antero-posterior (y) do deslocamento do centro de pressão (COP) que foram processadas pelo software Matlab 7.0 e correlacionadas com a pontuação do console pelo coeficiente de Pearson e Spearman, ambos com ($p < 0,05$). **Resultados:** Os resultados apresentaram correlação significativa apenas para o SL e RMSy, porém moderada (r = 0,5839). Quando comparada a pontuação do ST com as variáveis Área (r = 0,8164), RMSx (r = -0,6418) e RMSy (r = -0,8094) a correlação foi moderada a forte. **Conclusão:** Não encontrou-se correlação com nenhum dos testes do console quando comparados com a velocidade de deslocamento do centro de pressão medido na plataforma de força. Conclui-se que a pontuação do VG apresentou correlação significativa com as variáveis cinéticas, porém o método é pouco prático para ser empregado na avaliação clínica.

Palavras-chave: Jogos de Vídeo, Equilíbrio Postural, Acidente Vascular Cerebral, Reabilitação

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INTRODUCTION

The advance of technology has influenced not only the field of exact sciences, but also the area of health. This is the case of applying virtual environments (VE) in physical rehabilitations that use videogames (VG) as interfaces.[1] These videogames allow users to interact with virtual objects projected on monitors and to perform in motivating environments with different modalities of feedback, especially visual and auditory.[2] This new modality of treatment has become accessible to clinics and rehabilitation centers starting with the popularization of seventh generation videogames[1] that use a pressure-sensitive balance platform as an interface, allowing the user to control virtual characters while practicing such things as aerobic activities, balance, and muscle strenghtening.[3] Before the games, the videogame proposes a balance evaluation, scored by a percentage of stability that is then given to the user.[3]

In a study with 45 volunteers, Wikstrom[4] correlated the score obtained in the seventh generation VG balance tests with classic conventional balance evaluation data in order to use the VG balance tests as a clinical evaluation. The volunteers were submitted to evaluation through three balance tests proposed by the VG called single-leg stance, star excursion balance test and Balance Error Scoring System, and 12 balance activities from the Wii Fit (Basic Balance, Agility, Walking, Steadiness, Single Leg Stance, Deep Breathing, Tree, Standing Knee, Palm Tree, Single-leg Extension, Single-Leg Twist, and Sideways Leg Lift). The results of this VG balance test showed a weak correlation with conventional tests. This demonstrates that the balance evaluation by the VG tests may not be the most usable in clinical practice.

In a recent study, Heise[5] evaluated the scores obtained by two postures in a Yoga game in which the volunteers remained in a unipedal standing balance. The 29 volunteers were instructed to perform the postures proposed by the VG, where the videogame platform was positioned on a force platform. The variables related to the Center of Pressure (COP) were then correlated with the scores obtained by the game. Also in this study, it was found that the game could not be used as a valid measurement to evaluate balance.

Although the literature indicates some studies that investigated the performance of users of VG that use a balance platform,[4,5] there is no report in the literature of a balance evaluation proposed by the VG based on validated kinetic parameters, which raises doubts on whether the stability percentage supplied by the VG really represents an estimate of the postural control of its users. That is what motivated the present study.

Having these results, it will be possible to understand whether the score supplied by the VG balance tests can be used as a clinical evaluation to aid health professionals in such things as quantifying the balance of patients with orthopedic and neurologic complications.

OBJECTIVE

In this way the objective of the present study was to correlate the scores obtained in the balance tests with the VG platform with the kinetic variables supplied by a force platform.

METHOD

Participants

This study was approved by the ethics committee of the Hospital das Clínicas of the University of São Paulo, School of Medicine, under protocol Nº 5954.

Four volunteers participated in this pilot study: two with encephalic vascular accident (EVA) and two with cranioencephalic trauma (CET); they had those conditions for more than one year and were part of the physical rehabilitation program of the Physical Medicine and Rehabilitation of the Hospital das Clínicas of the University of São Paulo, School of Medicine. The study promoted the evaluation of balance in individuals with different clinical diagnoses, but who had posture control alterations in common.

The exclusion criteria were having muscle tone greater than 1+ on the modified Ashworth scale[6] in the soleus, gastrocnemius, anterior tibialis, quadriceps, and tibial ischial muscles, considered muscles of great importance in maintaining balance and postural control; muscle strength less than grade 3 in the muscles mentioned; atrophies and deformities in the lower limbs that would limit the movement amplitude of the hips, knees, and ankles; cognitive deficits and psychiatric disturbances that would make it impossible to apply the proposed therapy; visual deficiency that could compromise the performance of the therapy; previous illnesses that could interfere in the evaluations; compromising of the cerebellum or of the vestibular system; obesity.

Experimental protocol

A clinical evaluation was made before the experimental protocol was initiated.

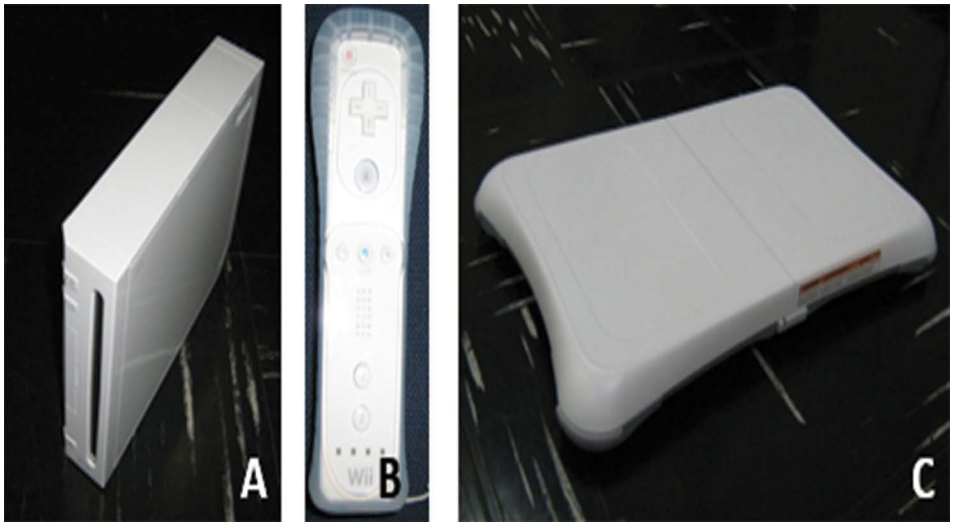
The VG Wii® from Nintendo was used for the experiment, composed by a console, a wireless manual control, and a balance platform called a balance board (Figure 1). The two last components mentioned are responsible for the interface between the user and the VG. For the present study, the wireless remote control was not used (Figure 1, B) as a therapeutic tool, but as an access to the VG menu.

The VG balance platform (Figure 1, C) is connected to the console (Figure 1, A) by Bluetooth.

The VG itself proposes a balance evaluation through some tests suggested randomly, such as: basic balance test, walking test, agility test, single leg test, and steadiness test. In this study, only the result from the Steadiness test (ST) and from the Single Leg test (SL) with bipedal support were correlated, since they supply a stability percentage. There is no clarification by the manufacturer on how these percentages are quantified nor are the parameters on which the VG is based known.

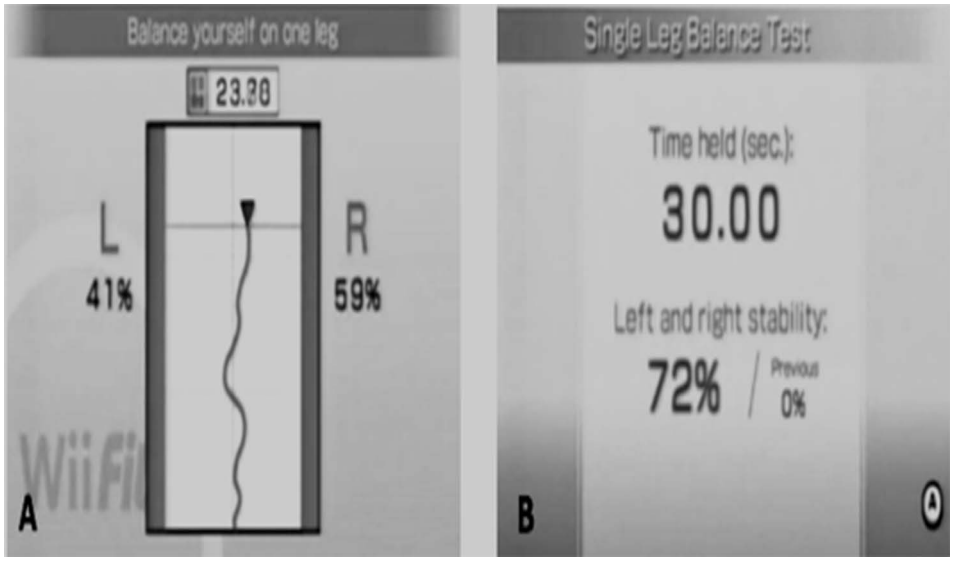
The SL proposes to evaluate the medial lateral balance in unipedal stance. The test is interrupted if the trajectory exceeds the reference limits presented. As a result, the VG gives a percentage of stability. A bipedal stance test is used in the present study (Figure 2).

The ST made on bipedal support evaluates the mediolateral and anteroposterior balance trying to maintain the COP trajectory at the reference center supplied in a crossing of lines; after 10 seconds of the test, the crossing moves through the screen, and after 20 seconds, it becomes hidden from the reference and from the point representing the COP (Figure 3).



A: VG console; B: Manual control; C: Balance Board

Figure 1. Videogame components



A: Image shown during the test with the COP trajectory to the right side (R) and left (L); B: Result, time, and percentage of stability of the ST

Figure 2. Single Leg Test

The VG balance platform was positioned down to the millimeter on the center of the AMTI force platform, with the larger axis of the VG balance platform remaining parallel to the y-axis and perpendicular to the x-axis. In this way, the x-axis supplied the COP trajectory in the anteroposterior plane and the y-axis, in the mediolateral plane. The 29" television was positioned two meters from the center of the platforms and centered on them (Figure 4). For the safety of the volunteers, the sides of the platforms were covered with mats and a therapist was always alert beside the volunteer to prevent possible falls.

As shown in Figure 4, the participants were instructed to remain in a bipedal stance on the VG balance platform and to perform the balance tests as instructed by the VG as viewed on the television. The capture of the kinetic variables by the force platform was initiated and finished in accordance with the beginning and end of the test, which were announced by sounds emitted by the VG. Three trials were made for each one of the tests (ST, SL). The VG's percentage of stability, supplied at the end of each game was recorded by the researchers. The data from the AMTI force platform were stored and processed later.

The force platform data was collected at a frequency of 200 Hz and subsampled at 100 Hz. The raw data from the COP position for each axis was submitted to a second order low-pass filter, critically damped at a frequency of 1050 Hz and stored in an Excel® spreadsheet. Finally, the software Matlab 7.0 (Mathworks, Inc) was used to calculate, with its own routines, the area, average velocity (AV), and average squared value, known in the literature as Root Mean Square (RMS) of the position in the medial lateral (x) and anteroposterior (y) directions.

Statistical Analysis

For the statistical analysis, the Pearson linear correlation test was used, adopting a significance level of $p < 0.05$. The data was quantified by the Matlab 7.0® software.

RESULTS

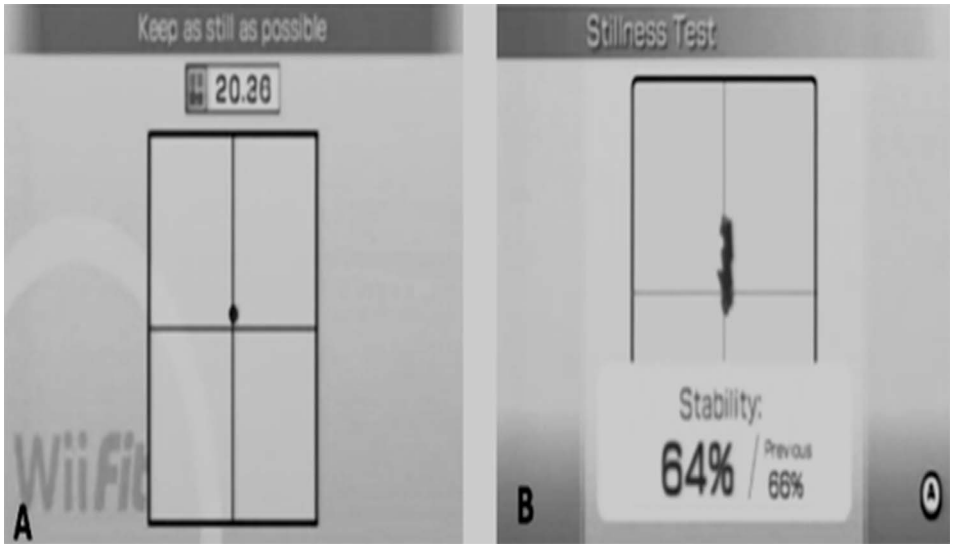
The data from the clinical evaluation of the participants is shown on Table 1.

Table 2 shows the results obtained from the correlation tests.

In the SL results, only the RMSy showed significant correlation, although moderate. However, in the ST, the variables Area, RMSy, and RMSx were significant and showed correlations from moderate to strong.

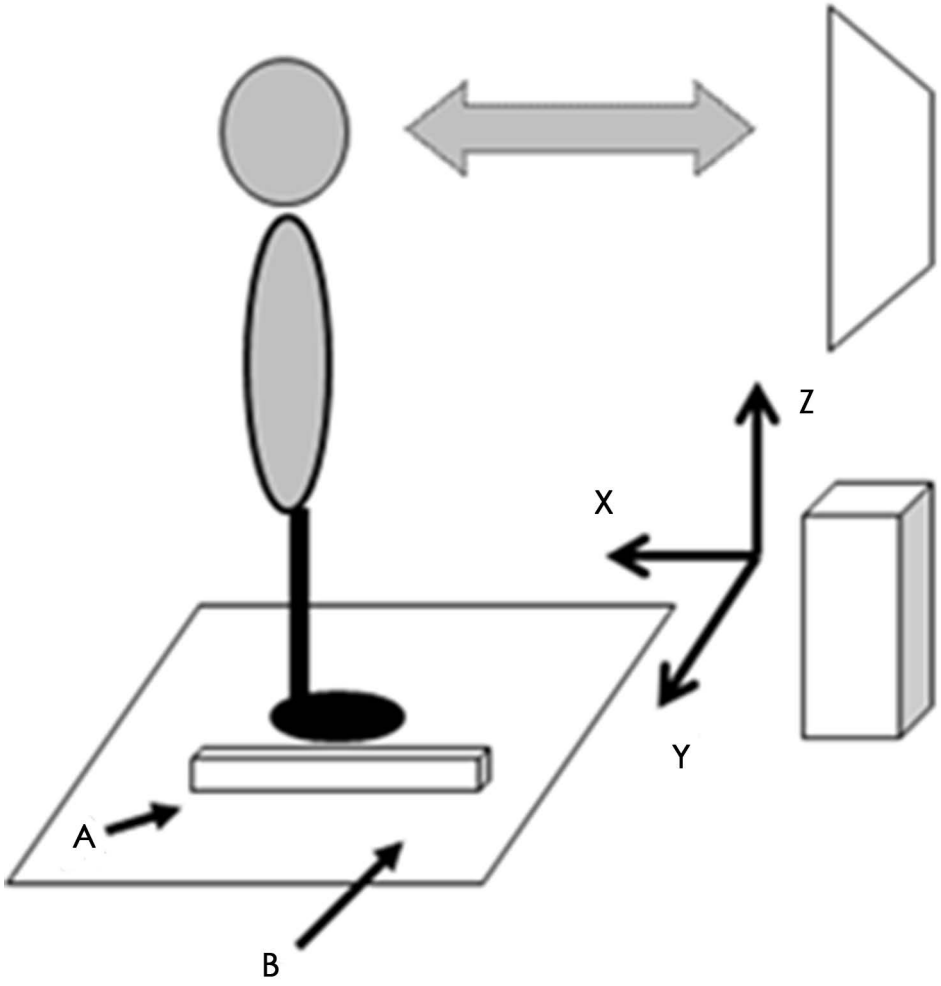
DISCUSSION

Many authors have made studies to understand what postural control is and what is indicated by the kinetic variables in its evaluation. Shumway-Cook[7] defines postural stability - the balance of the body - as the capacity to maintain the center of mass within the limits of the support base, which are called stability limits. It is known that the conservation of balance even in the static position is a dynamic process that involves the action of many muscular forces and that the vertical projection of these forces falls on the COP. Based on these concepts, the kinetic variables relative to the COP become relevant measurements to the evaluation of postural stability. The greater the COP sway,



A: Image shown during the test; B: ST result

Figure 3. Steadiness Test



A: VG balance platform; B: AMTI force platform

Figure 4. Diagram showing the positioning of the volunteer according to the Movement Laboratory reference system (x, y, and z)

the less the postural stability, since it is closer to the limit of stability.

As for the findings in this study, for the posture control, observed by the use of the VG balance platform on the force platform, it was possible to confirm, for the SL balance test, a moderate correlation with the RMSy variable, and for the ST, the area, RMSy, and RMSx variables showed a moderate to strong correlation. For the other variables of velocity and movement distance of the COP, no significant correlation was observed. One of the possible reasons for these findings is having used the test with bipedal support instead of unipedal support, as recommended by the VG. The bipedal standing position may have offered greater stability.

The RMS is described as to its relation to the effectiveness of the postural control system, for what it means to the level of stability reached by the activations of the muscular system.[8] According to Cornilleau-Peres,[9] the RMS measurements are related to the range of movement that directly influences the calculation of the movement area of the center of pressure. It can be seen that in the two balance tests evaluated in this study, the main correlation found was with the RMS. For a kinetic analysis, it can be said that this correlation indicates that the result obtained by the VG is based on the level of stability reached by the postural control system, and which justifies the name given to the test result: % Stability.

The literature points out some studies that correlate the scores from VG tests or exercises used in the present study with other traditional forms of balance evaluation. Heise et al.[5] found results similar to those obtained in this study while evaluating the score for Yoga postures, however the correlation with the RMS was not strong enough to allow the test to be used as a balance evaluation. Similarly, Wikstrom[4] correlated the scores from some Wii® tests and activities with other conventional balance tests and found no significant correlation between the results and between the groups of healthy individuals and those who showed a history of injury on their lower limbs, concluding that the VG was not a reliable instrument.

Despite having found significant results with the score of the VG tests and the variable RMS of the COP, its application as a tool for the clinical or scientific evaluation of balance is questionable, because of the small number of participants evaluated as well as the sessions supplying little data for statistical analysis.

Table 1. Characteristics of the volunteers

Gender	Age	Height	Weight	Clinical Diagnosis	Functional Diagnosis	Time since injury
F	53	1.59	91.5	iAVE	Hemi to the L	2a
M	37	1.70	73.8	CET	Hemi to the R	7a and 9m
M	24	1.74	66.5	iAVE	Hemi to the L	4a
M	33	1.79	89.4	CET	Hemi to the R	1a and 5m
Ave	36.75 (24-53)	1.705 (1.59-1.79)	80.3 (66.5-91.5)	2 iAVE 2 CET	2 Hemi R 2 Hemi L	1a5m - 7a9m

F: Female; M: Male; iEVA: Ischemic encephalic vascular accident; CET: Cranioencephalic traumatism; hemi: Hemiparesis; L: Left; R: Right: y: Years; m: Months; Ave: Average

Table 2. Results of the correlation tests

R	Area	VMx	VMy	RMSx	RMSy
SL Score	- 0.4545	0.3135	0.0979	- 0.4056	- 0.5839*
ST Score	- 0.8164*	0.157	0.3229	- 0.6418*	- 0.8094*

SL: Single-leg test; ST: Steadiness test, * Significant results $p < 0.05$

Finally, the way in which the tests are made available by the VG make the ST and the SL hardly applicable, for they make the evaluators dependent on the selection of the test, since the order of selection of the balance tests is randomized by the VH itself. Therefore, the use of the VH balance platform, associated with softwares created specifically to evaluate and treat balance, as done by Young et al.[10] Clark et al.[11] and Gil-Gómez et al.[12] continue being more recommended.

Other studies with more volunteers, with distinct populations and that also investigate the other tests made available by the VG are necessary to give continuity to this study.

CONCLUSION

It is concluded by this study by all the kinetic variables observed in the two tests investigated, the variable RMS of the COP showed from moderate to strong significant correlation in the balance tests of the VG.

However, because the VG chooses the tests randomly, its clinical application is inefficient, which reduces the possibility of its application in rehabilitation.

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