Developing a Rapid Assessment Method to Estimate Berg Balance Scale Score of Elderly People

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Abstract. To prevent falls, many experts are committed to studying the balance of risk factors and assessment methods fall. Berg Balance Scale (BBS) is a clinical assessment method that most commonly used yet its characteristic of subjective and time-consuming may the consequence in different results. The purpose of this study is to use the force platform system parameters and measuring the amount of income derived factors information and related research of BBS findings and to explore the possibility of subjective and objective information to assess the assistance results. Thirty-eight elderly adults residing at the Tai Shun Senior Centre react to sit-to-stand (STS) action on the force platform with the ergonomic chair. Thereafter, 12 parameters recorded or derived from the recording of the force platforms on measured operation time and the change of force data, then assess the results of BBS for correlation analysis. The results show that the relevance of BBS and force-related parameters is lower than the relevance of BBS and time-related parameters. Whereas, Ls - seatoff (the duration from the onset of leg to the time of seatoff) has high correlation with BBS results. This achievement can be an effective initial assessment of early warning on the results of BBS elderly people's ability to, thus reducing subjective measurement results of possible bias.

Keywords: Falling · Fall risk · GRF · Sit-to-stand

1 Introduction

In terms of injury prevention, falls are one of the most ordinary accidents in the elderly. The incidence of falls will increase as age increases (Campbell et al. 1989; Alexander et al. 1991). The physical effects of aging, such as falters in vision, sensory perception, hearing, balance, muscle tone, and reaction times, in the elderly will increase falls and the resulting injuries. The external factors, such as insufficient lighting, the insufficient height of toilet seats, or uneven ground, are also possible root cause for increased falls in the aged (Spanley and Beare 1995).

In daily life, the elderly often results in reduced balance capacity and fall occurred due to the physiology of aging. Many experts are committed to studying the balance of risk factors and assessment methods fall in order to prevent falls. To decrease accidental falls in the elderly, many intervention programs have been developed. Currently, "sit-to-stand" (STS) movement is investigated using observational performance tests or

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performance measures to assess the risk of falling (Bogle and Newton 1996; Rogers et al. 2003). Observational performance tests which tend to be subjective, use several assessment tools that combine measures of balance with measures of gait and mobility to determine a person's risk of falling, such as the Berg Balance Scale (BBS; Berg et al. 1992) and the Tinetti Gait and Balance Assessment (Tinetti et al. 1986).

Berg Balance Scale (BBS) is a clinical assessment method that most commonly used yet its characteristic of subjective and time-consuming may the consequence in different results by the assessment of surveying for 30 min or an hour spent. In this respect, if timely and objective measurement equipment data is offered in the BBS supplemented with comparative assessment will help in providing experts and medical personnel for determining the right balance of the elderly person. The purpose of this study was to use the force platform system parameters and measuring the amount of income derived factors information and related research of BBS findings and to explore the possibility of subjective and objective information to assess the assistance results.

2 Methods

2.1 Participants

The participants were selected from thirty-eight elderly adults residing at the Tai Shun Senior Centre. The selection criteria were over 65 years old, no acute medical illness, such as coronary heart disease, heart failure, or pulmonary infection in the past 3 months, without orthopedic diagnosis, no muscular disease, Barthel Index score ≥ 60, Mini-Mental Status Exam score >17, and Instrumental Activities of Daily Living Scale score ≥ 7. To confirm that all the participants were able to complete all the test successfully. In the end of the study, twenty-one healthy elderly participants independently completed stand up action and the BBS score in 41 or more of the elderly (12 females, 9 males; *M* age = 69.4 yr., *SD* = 3.7; BMI = 24.1; *SD* = 4.1) to react to STS action on the force platforms with the ergonomic chair. The study was approved by Fo Guang University ethics committee. After a full explanation of the experimental project, the Informed consent was obtained from each participant and its procedures were provided. Table 1 shows the means and standard deviation of four standard geriatric assessments.

Table 1. Means and standard deviation of four standard geriatric assessments

Variable	BBS		BI		MMSE		IADL	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Elderly	47	3.62	95.5	3.59	29.90	0.94	7.71	0.46

2.2 Apparatus

The main aspects of the force platform system are force platforms, ergonomic chair, and a charge-coupled device (CCD) camera. The load cells detect the changes in component GRFs during the STS task. The mechanical structure consists of an ergonomic chair and two force platforms (buttock force platform, BFP and leg force platform, LFP). In this task, an experimental ergonomic chair was designed according to the suggestions of the American National Standards Institute (ANSI) and the National Standards of the People's Republic of China (GB). In addition, the angle of the seat plane and between the seat plane and back were set to be 4° backward and 100°, respectively according to ANSI. The depth and the width of the seat were set to be 40 cm and 45 cm, respectively. The height of the seat plane was adjustable, between 32 and 46 cm (GB). To avoid sliding or overturning, the ergonomic chair was fixed to the BFP (Fig. 1).

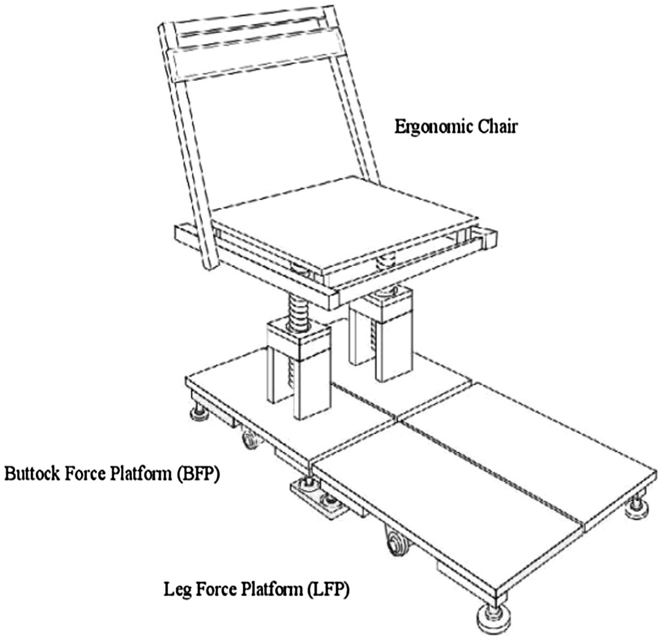

Fig. 1. Mechanical structure of ergonomic chair

In the present study, with the force platform, the GRF was defined as the force applied to the ground by the buttocks and/or the feet. Vertical GRFs were recorded from two separate force platforms (size, 500 × 500 mm; accuracy, 0.20 N) composed of eight load cells (Fig. 2). The distance between the force platforms was 10 mm. The pivot mechanism provides only one degree of freedom for the two separated plates; it was designed to prevent only three points being coplanar all because under such conditions, the boundary constraints of the remaining load cell may lead to incorrect data. Figure 2 shows the chair pivot mechanism of the force platform.

A video capture program was used to convert the video recordings of the STS movements into computer video files with a CCD camera. After force platform system data were confirmed on the video screen, the STS movements from the right side to the left and from front to back to capture images for subsequent observation was recorded by two digital video cameras. To show the movement from beginning to end, the computer video was then edited using Adobe Premiere 4.0 (Adobe Systems, San Jose, CA, USA). The layout of experimental setting is shown in Fig. 3.

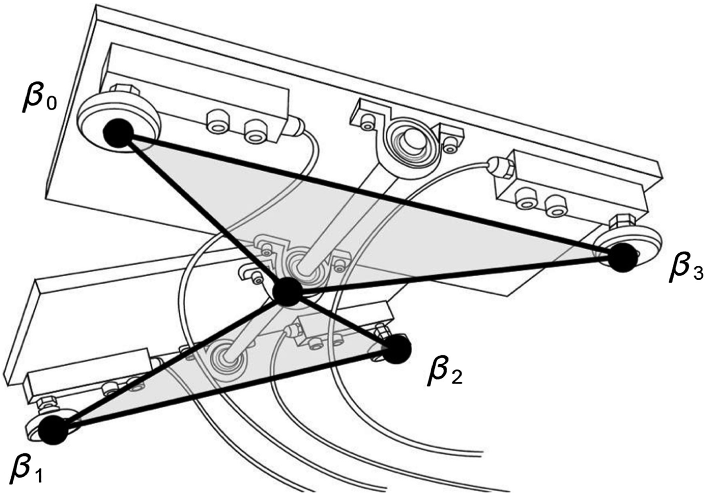

Fig. 2. Chair pivot mechanism of the force platform

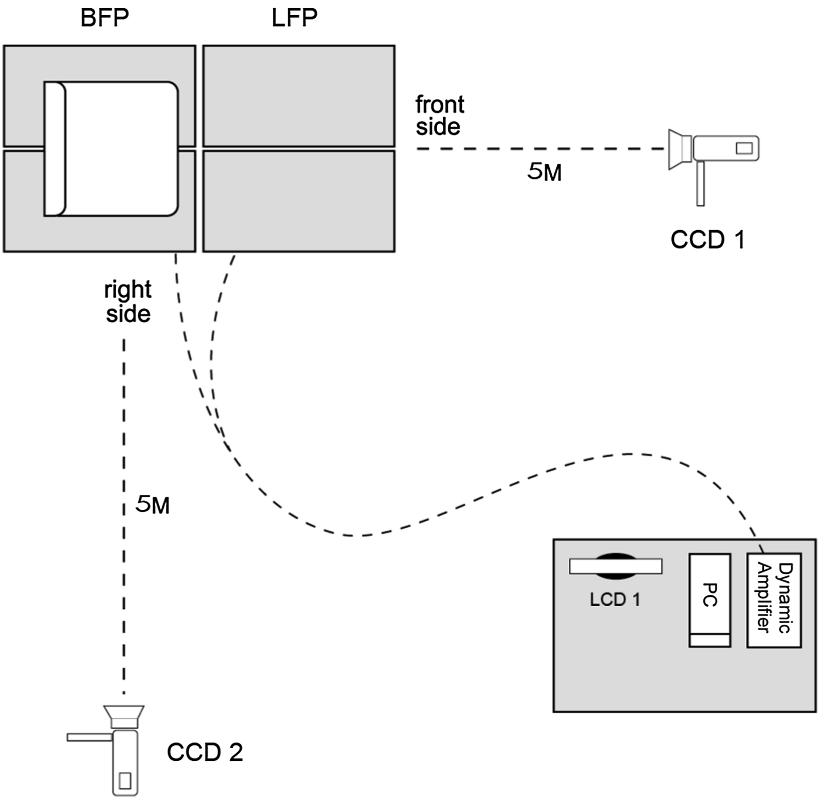

Fig. 3. Layout of the experimental setting

2.3 Procedure

First of all, participants sat on the experimental ergonomic chair on a buttocks force platform and their arms kept folded across their chest. In order to ensure that the trunk was leaning back in a standard position, the back support on the chair was used. Bare feet were positioned on the leg force platform together with the feet maintained 10° of the calf and vertical face. This sit status is the starting posture. No other restrictions were imposed on the initial position. To initiate the sit-to-stand movement, an auditory signal from the computer cued the participants. Each participant performed the task in a comfortable and natural manner and at a self-selected speed. Then, the task was performed in one trial, following two practice trials. The immediate response can be done if discomfort during the test. A registered nurse was present during all trials for safety.

2.4 Measurements

The selected ground reaction force parameters and time course of STS are as shown in Fig. 4. Two curves (Curve B, buttocks weight; Curve L, leg weight) describing the vertical GRF as a function of time were obtained from the force platforms. The sum of forces B and L showed Curve T. The time to stand up was calculated from these curves.

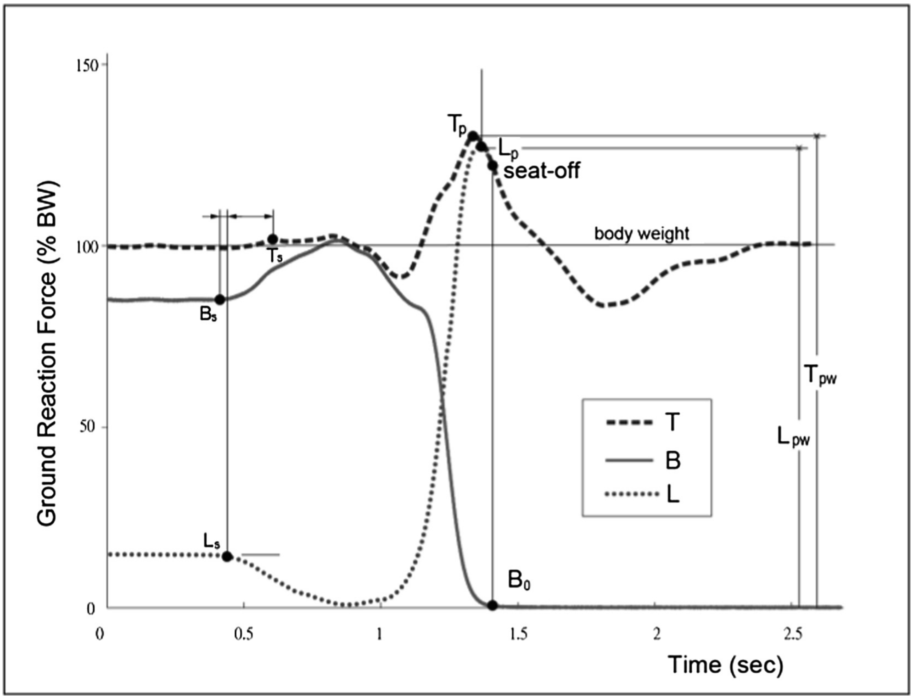

Fig. 4. Ground reaction force parameters and time course of sit-to-stand.

The onsets of Curves B (Bs), L (Ls), and T (Ts) were identified immediately after the action cue when the difference between the GRF at that time point and the previous value did not equal zero. Seatoff was defined as the time at which the thighs lost contact with the chair when the instant of Curve B was at zero (B0). Tp and Lp occurred when the GRF for Curves T and L, respectively, were maximal. Tpw and Lpw were the maximum forces of Curves T and L, respectively. The GRF oscillated following seatoff, and the sit-to-stand phase ended when the ground reaction force reached body weight. By using the moving average method, the recorded data were been smoothed before analysis (Box and Pierce 1970).

Thereafter, 12 parameters recorded or derived from the recording of the force platforms on measured operation time and the change of force data, then assess the results of BBS for correlation analysis. Each parameter is named Nomenclature as shown in Table 2.

Table 2. Nomenclature used in this study

Parameters		Description
Weight parameters	Tpw	The maximum ground reaction force of Curve T
	Lpw	The maximum ground reaction force of Curve L
Time parameters	Bs-Lp	Duration between Bs-Lp
	Bs-Tp	Duration between Bs-Tp
	Bs-seatoff	Duration between Bs-seatoff
	Bs-end	Duration between Bs-end
	Ls-Tp	Duration between Ls-Tp
	Ls-seatoff	Duration between Ls-seatoff
	Ls-end	Duration between Ls-end
	Ts-Tp	Duration between Ts-Tp
	Ts-seatoff	Duration between Ts-seatoff
	Ts-end	Duration between Ts-end

3 Results

The test results showed that among the 12 parameters that measured and derived by the force platforms, Ls-seatoff, the time-related parameters and its BBS score showed highly correlated with −.709 ($p < .01$). Moreover, when force related parameters Tpw and Lpw showed low correlation with BBS score, time related parameters like Bs-Lp, Bs-Tp, Bs-seatoff, Bs-end, Ls-Tp, Ls-end, Ts-Tp, Ts-seatoff and Ts-end showed significant correlation. Table 3 lists the function, mean of each independent variable including weight and time parameters of the sit-to-stand movement. The correlated coefficients of each factors and BBS score were also shown.

Table 3. The correlation of deformation parameter

Parameters	Function	Parameters		BBS score	
		M	SD	P	Pearson
Tpw	$(T_{pw})^{1/4} * \sqrt{BMI}$	11.65	1.68	.078	–.393
Lpw	$(L_{pw})^{1/4} * \sqrt{BMI}$	14.25	1.67	.077	–.394
Bs-Lp	$(B_s - L_s)^{1/4} * \sqrt{BMI}$	32.20	4.44	.003	–.616**
Bs-Tp	$(B_s - T_p)^{1/4} * \sqrt{BMI}$	31.59	4.47	.005	–.593**
Bs-seatoff	$(B_s - \text{seatoff})^{1/4} * \sqrt{BMI}$	32.63	4.39	.002	–.627**
Bs-end	$(B_s - \text{end})^{1/4} * \sqrt{BMI}$	36.17	4.28	.002	–.635**
Ls-Tp	$(L_s - T_p)^{1/4} * \sqrt{BMI}$	31.55	4.22	.001	–.683**
Ls-seatoff	$(L_s - \text{seatoff})^{1/4} * \sqrt{BMI}$	32.58	4.24	.000	–.709**
Ls-end	$(L_s - \text{end})^{1/4} * \sqrt{BMI}$	36.14	4.15	.000	–.694**
Ts-Tp	$(T_s - T_p)^{1/4} * \sqrt{BMI}$	30.54	5.55	.005	–.587**
Ts-seatoff	$(T_s - \text{seatoff})^{1/4} * \sqrt{BMI}$	31.75	5.21	.002	–.636**
Ts-end	$(T_s - \text{end})^{1/4} * \sqrt{BMI}$	35.59	4.76	.001	–.652**

**at significant level of 0.01 (two-tailed), significant correlation.
*at significant level of 0.05 (two-tailed), significant correlation.

4 Discussion

The results of this study showed that the correlation test between the original parameter score and BBS score, that both scored mostly with low and moderate correlation. Subsequently, attempts to correlate the BMI score with the BBS score were only moderately correlated with −.452 ($p = .04$). However, when the BMI values are incorporated into the construction of the future parametric functions, there are different discoveries.

After the setup of each parameter function, the results show that the relevance of BBS score and force-related parameters, such as Tpw (the maximum GRF of the sum of force buttock weight and leg weight) and Lpw (the maximum GRF of force leg weight) is lower than the relevance of BBS score and time-related parameters such as Bs-end (the duration from the onset of buttock to the end of STS) or Ls-Tp (the duration from the onset of leg to the time of the maximum GRF at Curve T). Whereas, Ls-seatoff (the duration from the onset of leg to the time of seatoff) have high correlation with BBS score results (−.709, $p < .01$). Hence, Ls-seatoff and BBS score had the chance, through regression analysis to create regression equation.

The current assessments of clinical balance were done by experts and professional medical personnel with the BBS assessment yet it may consume more time (30 or 45 min more) to assess with individual subjective judgments, possibility on resulting deviation in rating (Chang et al. 2013). The objective and time-saving features of the force platform system can be usefully supplemented with the information, that can assist experts and professional medical personnel on the assessment of balance.

In the past, there were a lot of researches using the force platforms to measure the standing movement of the elderly (Lindemann et al. 2007; Yamada and Demura 2005), obtained the data from the objective, was used to describe the standing movement with the factors of the elderly's fall risk acquisition research. Chang et al. (2010) also through the test of ground reaction force and composition force through two force platforms, which describes more clearly on standing movements, such as Tp, Lp and seatoff key points in order to clarify the sequence, which has made a great contribution. Yet a number of high-priced force platforms may be the obstacle for universal application in the future. Figure out how to use only one piece of force platform to obtain the necessary data and information, will be the goal of the next research phase. This stage of research can be an effective initial assessment of early warning on the results of BBS elderly people's ability to, thus reducing subjective measurement results of possible bias.

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