Reliability and validity of center of pressure measures for balance assessment in older adults

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Abstract. [Purpose] This study was conducted to assess the reliability and validity of center of pressure-based parameters for balance assessment. [Subjects and Methods] Two hundred and forty older adults were evaluated using a force platform and the Berg Balance Scale at 1-week intervals. The intra-class correlation coefficient and the Pearson correlation coefficient were used to test reliability and validity respectively. [Results] The reliability of the 12 selected center of pressure measures was satisfactory (intra-class correlation coefficient = 0.75–0.99) and the validity between the parameters and the Berg Balance Scale was moderate to good (r = −0.62 to −0.88). [Conclusion] Center of pressure-based parameters are reliable and valid measures in older adults.

Key words: Force platform, Center of pressure, Postural balance

INTRODUCTION

There are two common ways to evaluate the postural balance of older adults. Functional balance scales, which assess balance through functional tasks, are one type of balance measure frequently used in clinical and research settings1). Functional balance measures, such as the Berg Balance Scale (BBS), have practical advantages, including ease of use and low cost1). However, these scales cannot quantify postural balance accurately.

Another method is to measure the excursion of the center of pressure (COP) with a force platform during quiet standing. Using a broad range of algorithms, many COP-based parameters are calculated by a stabilometric platform2). However, COP measures have intrinsic variability which can affect the reliability and validity of postural control outcomes. Therefore, the reliability of postural control measurements should be established. The aim of this study is to examine the test–retest reliability and the validity of COP measures in older adults.

SUBJECTS AND METHODS

A total of 240 older adults (mean ± SD age: 70.1 ± 8.5 years, body mass index: 23.8 ± 3.7 kg/m², male/female: 124/116) from the local community in Shanghai were recruited for the study. All participants were informed about the aim of the study and gave written informed consent. All procedures were approved by the Chinese Ethics Committee of Registering Clinical Trials. People aged more than 60 years who could walk with or without assistive devices for at least 20 m were included. Those with cognitive impairments and any orthopedic or neurological pathology that could influence balance assessment were excluded.

All participants were evaluated initially using the BBS and a force platform (Balance-A, NCC, Shanghai, China) and were then reassessed at 1-week intervals. Participants were asked to stand on the force platform with eyes open and eyes closed for 30 seconds, after which they were asked to sit down on the platform for 30 seconds.
This study showed that VM to be acceptable for evaluating balance in older adults when standing with eyes open or eyes closed, and in seated positions.

Based assessment consists of 14 balance-specific activities ranging from sit-to-stand to standing on one leg. The scale has strong inter-rater and intra-rater reliability and correlates well with other clinical balance scales. COP-based parameters were measured using the Balance-A. This device consists of two force platforms and connects to a personal computer and monitor. One force platform is used to measure foot pressure and the other for bottom pressure. Each force platform is mounted on four force transducers. These transducers measure vertical ground reaction forces, which form the basis of subsequent calculations of COP. Although many COP-based variables have been proposed in the literature, this study focuses on twelve balance parameters: (1) total path length (P, cm); (2) path length along the medial-lateral axis (P_ML, cm); (3) path length along the anterior-posterior axis (P_AP, cm); (4) maximal range of sway in the medial-lateral direction (M_ML, cm); (5) maximal range of sway in the anterior-posterior direction (M_AP, cm); (6) sway angle (SA, °); (7) mean sway velocity (V_M, cm/s); (8) velocity along the medial-lateral axis (V_ML, cm/s); (9) velocity along the anterior–posterior axis (V_AP, cm/s); (10) covered area (A, cm²); (11) average center displacement deflection along the medial–lateral axis (D_ML, cm); and (12) average center displacement deflection along the anterior–posterior axis (D_AP, cm).

Data were analyzed with SPSS software (version 21, IBM, New York, USA). The intra-class correlation coefficient (ICC) was used to assess the test-retest reliability of the two balance assessments. ICC values between 0.80 and 1.00 indicate high reliability, those between 0.60 and 0.79 indicate moderate reliability, and those below 0.60 indicate low reliability. To investigate validity, the Pearson correlation coefficient was used to test the degree of correlation between COP parameters and the BBS. A Pearson r value > 0.75 indicates good validity (> 0.90, excellent); 0.50 to 0.75, moderate to good validity; and < 0.50, poor validity.

### RESULTS

The test-retest reliability data of the COP-based parameters under three conditions are presented in Table 1. ICC values for all COP-based variables in those three conditions were satisfactory. The V_M in the seated position showed the highest value (ICC = 0.99). The lowest ICC value was 0.75 for M_AP in the seated position and V_AP with eyes open. The 95% confidence interval values were greater than 0.63. The validity of the force-plate variables for the three positions was evaluated by correlation analysis with the BBS, as presented in Table 2. The analysis revealed moderate to good validity between the COP-based parameters and the BBS (r = −0.62 to −0.88), but there were no parameters with excellent validity (r > 0.90).

### DISCUSSION

The test-retest reliability and the validity of the twelve COP-based measures obtained with the force platform were found to be acceptable for evaluating balance in older adults when standing with eyes open or eyes closed, and in seated positions. This study showed that V_M in the seated position had the highest reliability (ICC = 0.99). V_M and P_ML were the most reliable balance parameters (ICC = 0.94–0.99) in all three conditions. Moderate to good validity was found between the COP-based parameters and the BBS.

Previous studies have tested the reliability and validity of COP-based parameters for balance assessment in older adults using different methods. For instance, Silva et al. (2013) assessed the test–retest reliability of balance parameters obtained with a force platform in 28 healthy older adults during one-leg stance. The test-retest reliability of all selected COP-based measures was acceptable (ICC = 0.40–0.85), with the best ICC scores observed for V_M in older participants. Lin et al. (2013) reported...
that VM was the most reliable measure (ICC = 0.91–0.95) for within-day and between-day measures in 16 older healthy adults with eyes closed, and found that within-day reliability was better than between-day reliability. Condron and Hill reported that there was a moderately high correlation between performance on the Timed Up & Go (TUG), gait velocity, and stride length with COP-based measures in 20 healthy older adults. Sturnieks et al. examined the validity between the Swaymeter and force platform sway measures under eyes open and eyes closed conditions in 29 older adults and found that the Swaymeter measures were moderately to strongly associated with the COP measures ($r = 0.560–0.865$). The current study adds to these findings.

The present study had some limitations. First, the study only tested the correlation between the COP-based parameters and the BBS. However, numerous functional balance tests are used to clinically evaluate postural balance, such as the Performance-Oriented Mobility Assessment and TUG. Future studies should assess the validity between the COP-based parameters and these scales. Second, people unable to walk with or without assistive devices at least 20 m were excluded from the study. This might limit the generalization of the findings. Additionally, the results of this study are not suitable for generalization to older adults with severe balance dysfunction.

The reliability and validity of COP-based parameters have been investigated in a variety of patient populations. This study indicates that COP-based parameters are reliable and valid measures in older adults. The test–retest reliability of the COP-based measures was found to be acceptable, with better ICC scores observed in VM and PML. The twelve COP-based parameters displayed moderate to good validity when compared with the BBS in older adults. As older persons have a higher risk of falling, future research should assess the capacity of the COP-based parameters to predict falls in older adults.

**ACKNOWLEDGEMENTS**

This study was funded by the Science and Technology Commission of Shanghai Municipality (No.13DZ1941606). Dr. Zhen Li and Yan-Yi Liang contributed equally to this work. Dr. Jing Sheng was a co-correspondent.

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